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THE IMPORTANCE OF BEING OLDEST:

AGEISM AND MEMORY IN THE AGEING SOCIETY

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To my grandmothers Noemi and Nina,

to the unknown grandparents,

the ones half-known

and all the ones met during these years.

The most spontaneous and, at the same time, complicated part is that of the acknowledgments. In a few lines of meditation, reflection and awareness, we try to give suitable space to the people who have been part of a personal, cultural and professional path.

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ABSTRACT

Since 2002, when the World Health Organisation laid down the principles for promoting active ageing-oriented economic and welfare policies, psychological literature in ageing has also been developed following these principles. The doctoral thesis provides studies on ageing that focused on two main themes: on the one hand, the psychosocial factors in ageing comprehensive of attitudes and perception of one's age; on the other hand, cognitive processes most affected in healthy ageing, especially episodic memory, and tools to train and evaluate them.

The thesis is, therefore, divided into two sections.

In the first part, the themes of ageism and attitudes towards one's ageing process will be explored through two studies that use virtual reality as a methodology and approach capable of simulating the ageing process. In a first study, we investigated the impact of a visuo-tactile embodiment stimulation in modifying negative attitudes towards the elderly in three different age groups through the use of virtual reality. In a second study, given the importance of avatar characteristics in virtual reality studies, we aimed to create a dataset of digital bodies and faces that can be used later for studies that combine virtual reality and attitudes towards the elderly.

In the second part, we will focus on episodic memory as a domain related to the self and well-being. Two studies will be presented: a cognitive training created by us that aims to stimulate the components of episodic memory, and a task that, exploiting the representation of mental timeline and distance effect, has the objective of studying the mechanisms of learning of similar- personal events in young and old.

ABSTRACT ITALIAN VERSION

Dal 2002, anno in cui l'Organizzazione mondiale della Sanità ha sancito i principi per promuovere politiche economiche e di welfare orientate all'Active Ageing, anche la letteratura in campo psicologico operante nel settore dell'invecchiamento si è mossa in accordo con questi principi. La tesi di dottorato presenta degli studi inerenti all'invecchiamento che vertono su due tematiche principali: da un lato i fattori psicosociali nell'invecchiamento intesi come atteggiamento e percezione della propria età; dall'altro i processi cognitivi maggiormente colpiti nell'invecchiamento sano, in particolar modo gli aspetti di memoria episodica, e gli strumenti per allenarli e valutarli. La tesi è dunque divisa in due sezioni. Nella prima parte saranno approfonditi i temi dell'ageismo e degli atteggiamenti verso il proprio processo di invecchiamento, attraverso due studi che utilizzano la realtà virtuale come metodologia e approccio in grado di simulare il processo di invecchiamento: in un primo studio attraverso l'utilizzo della realtà virtuale abbiamo indagato l'impatto di una stimolazione di embodiment visuo-tattile nel modificare gli atteggiamenti negativi verso gli anziani in tre gruppi di età differenti. Nel secondo studio, data l'importanza delle caratteristiche degli avatar negli studi di realtà virtuale, abbiamo creato un dataset di corpi e volti digitali che potranno essere utilizzati successivamente per studi che combinano la realtà virtuale e gli atteggiamenti verso gli anziani. Nella seconda parte sarà invece approfondito il dominio della memoria episodica come componente relativa al self e indirettamente legata ai benessere e ai vissuti di preoccupazione e ansia relativi alla perdita di memoria. Verranno presentati due studi: un training cognitivo da noi creato con l'obiettivo di stimolare le componenti di memoria episodica e un compito che, sfruttando la rappresentazione della *mental time line* e del *distance effect*, ha l'obiettivo di studiare i meccanismi di apprendimento di eventi simil-personali in giovani e anziani.

"If you mix the mashed potatoes and sauce, you can't separate them later. It's forever.
The smoke comes out of Daddy's cigarette, but it never goes back in.
We cannot go back. That's why it's hard to choose. You have to make the right choice.
As long as you don't choose, everything remains possible."

— Mr. Nobody

0. A brief history of time

I have always been fascinated by time. By how we perceive it, by what it means, by how we use it. The time that passes and makes us grow old. The time that rewinds with memory. Memories: that is what is left at the end of our lives. In search of what it meant to grow old, I began to believe that memory could be the only thing that keeps us young.

A brief history of time, age and memory.

The pandemic has stopped everything, literally. Activities, commitments, goals. Time has dilated into eternal expectation. Furthermore, we seem to have aged suddenly. At the same time, however, we have had the opportunity to begin to appreciate the quantity and quality of time we want to spend. We started saying no: to ourselves and our need to fill our time, removing that oppressive feeling, that time is never enough, and to others, to whom we do not want to give the impression of not "live" enough.

Our conception of absolute time understood as something beyond the events that follow is a Newtonian tradition that we are accustomed to thinking of as universal and eternal.

Without entering "physically" into the debate, we are more accustomed to believe that everything has its time, a time in physics called "proper", to contrast it to the absolute time that we usually measure. If we talk about subjective age, we were already used to thinking in these terms. Despite our attempts to measure individuals' chronological age, gerontology has long known that each age differently. Numerous factors affect the age and time lived, including the attitudes we have towards our age.

The perception of one's ageing process and "passing of personal time" is a multidimensional concept, influenced by different cognitive, affective and behavioural processes. It can be quantified in the same terms as the chronological age: the age I felt (I am 40 but I still feel 18), the age I wanted (I would still like to have 30) and the age I felt (I think others would give me 30 years for how I look). Of course, the perception of age is a complex construct that includes satisfaction with the ageing process, how time is spent, and how much can affect the quality of life.

Moreover, the perception of time is a dimension not new to psychology. The psychological dimension of the passage of time is influenced by other dimensions cognitive and emotional. For example, the presence of scary bodily and facial expressions, increasing the organism's activation, also increases the internal clock, so that time is perceived as faster (Droit-Volet and Gil, 2016).

How do we see the time that we live in? What do we do with it? Are we convinced that there is a time to do some things? Are we serial procrastinators? Do we reason for socially imposed life stages that we want to respect up to down (graduation, marriage, children)?

Are we younger if we do more activities during the day and spend our time better? Do we feel older if we reach some life events after than our peers? This chasing our own time, in some cases, leads us to saturate our life with activities, commitments, goals with the feeling that time is never enough. May it never be enough for us? May we grow old before time without having done what we wanted?

Time and ageing are strictly connected. Moreover, memory allows us to travel through time. Our "proper" time. We can remember the past, being present and conscious and imagine the future. There is no limit to memory.

For this reason, I thought that if I had to write a "brief" part of the "history of time", I would have to start from ageing and memory.

“Because everything that begins must end.
What causes us to suffer is not in the past or the future:
it is here, now, in our memory, in our expectations.
We long for timelessness, we endure the passing of time: we suffer time.
Time is suffering.”

- Carlo Rovelli in “The order of time”

1. Live longer and prosper: ageing well is the new challenge of the century.

1.1. What ageing feels like

What does it mean to grow old? The answer to this question is not that simply as it would appear. We commonly associate the ageing process with physical and mental changes that everyone could possibly experience at the end of their life. However, becoming old is a dynamic and multidimensional process that is ascribable to biological changes and social and psychological aspects.

Instead of talking about "age", we can talk of ages. For instance, the first sign of age refers to biological changes during the life span. We can quantify it through chronological age, which indicates the real age of each one. Moreover, some physical changes differ from individual to individual, depending on the combination of genetic factors and lifestyle. Although development trajectories in the ageing process are similar among populations, each individual becomes old differently.

Together with biological changes, we can consider the psychological and social aspects. The psychological age refers to the attitudes and beliefs toward one's ageing process and can be defined in terms of subjective age. The social age refers to the role you have in society according to your age: young and old are different in different social life domains, such as work or civic engagement. The age and ageing process can be studied from different domains and points of view, which is a very complicated process.

According to life expectancy, the interest in ageing follows the common knowledge and view of ageing from a historical point of view. *"Senectute ipsa morbus est".* With this sentence, in ancient times, age was associated with illness. However, close to nothing has changed since then.

Before life span theory and still nowadays in some cultures, the development curve follows a negative linear pattern, in which most of the abilities, skills and cognitive demand in the older human being are marked by constant losses. For instance, Salthouse (1996) showed that processing speed increases from childhood until 25 years old and then declines once one's become older.

In 1987, Paul Baltes proposed a new life span psychology model, which aimed at studying regularity and change in behaviour throughout the life cycle. The goal was to spread and increase knowledge of the mechanism of life-long development, differences, and similarities among individuals in brain development and plasticity level (Baltes, Reese, and Nesselroade, 1977; Lerner, 1984; Thomae, 1979).

The fundamental principles of this new approach are life span development, multi-directionality, development as constant gain and loss process, plasticity, historical embeddedness and contextualism as a paradigm.

The first principle considers ontogenetic development as a lifelong process. Unlike the previous approach, for which only infants and schoolchildren were considered for development, no age period is considered specific for development. At all steps of life span these are both continuous and discontinuous processes at work. Multi-directionality considers different trajectories in different domains: for instance, one domain or behaviour could increase and improve during the life span, whereas other domains could decrease. This cycle during life span could be seen as dynamic, and the general mechanism of development can be characterized either by gain, in domains where there is an improvement, or by loss, in the domains where there is some decline. Moreover, this approach allows studying plasticity, defined as the difference in brain structure modifications between different people, in which living conditions and experiences play a crucial role.

From a cultural perspective, ageing is not directly associated with the concepts of "loss" and "decline"; there are changes in almost all spheres of the individual, including biological, physical, brain structure and function, and cognition. If happening in a healthy way, becoming older is associated with changes in almost all individual spheres, including physical condition, the senses, brain function, and cognition (Vallet, 2015).

Each sensory organ is affected by ageing (Ulfhak et al., 2002), with an overall decline in perception, with a higher perceptual threshold (Fozard and Gordon-Salant, 2001), in motor system, with a loss of both motor neurons and muscle mass (e.g., Vandervoort, 2002), and a decrease in strength, resulting in gait and balance alterations (Boelens et al., 2013). Biological and perception changes go hand in hand with several modifications in cognition.

Elderly adults show the most significant decline in the cognitive speed of processing (Salthouse, 2000), attention and executive functions (Greenwood, 2000), as well as in some aspects of episodic memory, mainly in free recall (Danckert and Craik, 2013). In contrast, most aspects of language, semantic memory (general knowledge about the world), emotion regulation (Cartensen et al., 2003; 2011) and more mechanical aspects of attention or memory remain preserved (Glisky, 2007). During a cognitive task carried out in a experimental context, healthy older adults are in general more susceptible to the effects of interference and distraction, with an overall difficulty in dual tasks and inhibitory processes. Compared to younger individuals, the elderly show either increased or decreased functional brain activity. The first one is associated with a compensatory mechanism in which other areas are involved in overcoming other regions limitation. Instead, decreased brain activity has typically been interpreted as a general reflection of cognitive deficits. As we shall see in more detail in the second chapter, several studies provide evidence of the compensatory hypothesis. The first study of this mechanism shows an increased activity of the prefrontal cortex area during a memory task and the bilateral activation of this region compare to younger adults' activation (Grady et al. 2005). However, the increased activity in older adults compared to the younger ones is always associated with a better performance. Therefore, it is not always possible to talk about a compensatory process; higher recruitment sometimes reflects a more significant demand for neural resources and less efficient use of the same resources, or even a reduction in the selection of responses (the so-called dedifferentiation) (Grady, 2008; 2012). From a functional point of view, literature also focuses on functional connectivity within extended brain networks. One of these extended brain networks is the "default network": it is activated in a resting and mind wandering condition, and its activity tends to decrease during cognitive tasks or tasks that requires specific attention (Gusnard et al., 2001; Spreng and Grady, 2010). This reduction of default network activity during a cognitive task is less pronounced in the older adults (Andrews-Hanna et al., 2007; Duzel et al., 2011). A reduced functional connectivity has been found during a working memory task and period of rest (Sambataro et al., 2010; Partk et al., 2010). Since default network modulations are associated with the degree of task difficulty and with the performance of an older individual on a different domain and on cognitive tasks, a deficit in the activation and functionality of the default network in advancing age may suggest a deficit in resource allocation during the task and explain some age differences in cognitive performance.

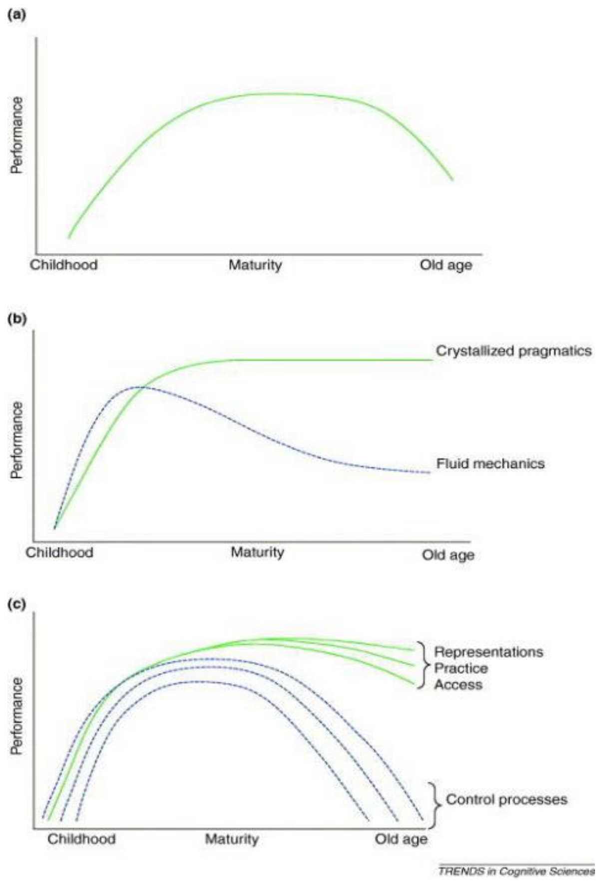

Figure1. 1. Three speculative models of cognitive change across the lifespan. (a) A single 'mirror-image' view; performance rises in childhood, is maintained in middle age and declines in late adulthood. (b) The different lifespan trajectories of crystallized intelligence ('cognitive pragmatics') and fluid intelligence ('cognitive mechanics'). The first are relative maintained and the second one progressively lost. (c) A more realistic version of (b), in that representations are generally well maintained at older ages, but some knowledge is either lost (especially with lack of practice) or becomes inaccessible. Modified from Craik (2006).

Craik (2006) proposed a comprehensive model (Fig. 1.1) of the cognitive change of ageing. According to the author, those processes concerned with representation (schemas, bases for memory and general knowledge of the world) and control (set of fluid operations). Furthermore, their interaction changes during the lifespan, determining cognitive abilities. In Baltes' Life Span theory, the representational knowledge continues to accumulate throughout adulthood and remains stable in older age. On the other hand, cognitive control represents the strength, speed and complexity of the cognitive material to manage decline with age. Park referred to the general knowledge with the term “crystallized" intelligence or cognitive pragmatics. The control is relative to “fluid” intelligence or cognitive mechanics. As represented in Fig 4, this model aims to introduce a fundamental cognitive ageing study approach. While in the "mirror image view", also called reversed U shape, performance rises until adulthood and declines with older age, with wide differentiation in different domains of cognitive or perceptual processing, this model allows to consider the elderly in their complexity and to appreciate individual trajectories, the environmental influence and the resources of older people.

1.2.Why should we talk about ageing?

From a demographic point of view, research on ageing is essential due to population ageing. Population ageing is defined as the increase of the total population over 65 years of age as a proportion of the national population and the comparison with the younger portion of the population. The age modification in society could depend on fertility (how many children are born), which is currently declining, but also on life expectancy (how long people live), which is currently improving. These two factors combined cause the incrementation in the percentage of older adults. Moreover, this prolongation of life is causing several modifications to the economic, cultural and social level. For instance, the family structure is changing, and there are more family with an extended nucleus and more grandparents and great grandparents for every grandchild.

Furthermore, these new family structures could increase the burden on individuals aged 40 to 59, the so-called "sandwich generation”, since they have to manage to work and provide for both older and younger family members. At a macro level, ageing affects social, political and economic decisions (Harper, 2014).

Moreover, the economic crisis of 2008 sped up population ageing in Italy (Reynaud and Miccoli, 2019) which has led to more problems in demographic, social and economic context for the country.

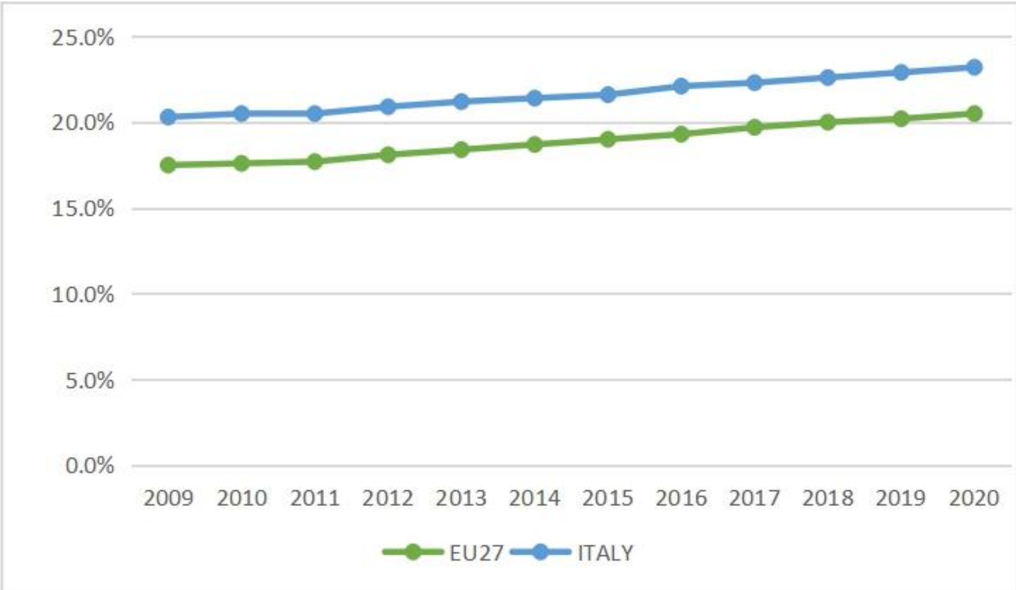

Figure 1.2. The proportion of the population aged 65+ years on January 1, years 2009-2020 in the European Union (27) and Italy. Source: Elaboration from Eurostat data.

As we can notice from Figure 1.2, the percentage of the elderly population in Italy is higher compared to the average of the other European countries and this percentage has a positive trend: in 2020 the elderly population constituted one-quarter of the national population. Moreover, in Italy, the group of young-old (65-79) represents most of the elderly population (See Fig. 1.3).

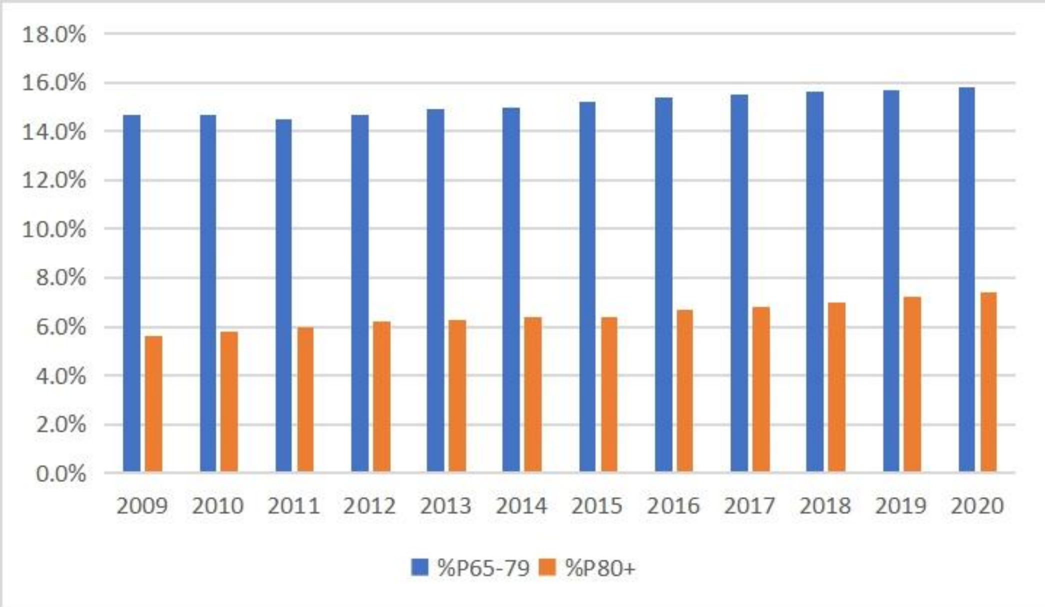

Figure 1.3 The proportion of the population aged 65+ and 80+ years on January 1, years 2009-2020 in Italy. Source: Eurostat data.

Increased life expectancy and decrease mortality lead to a substantial rise in the older population. Nevertheless, living longer is not equal to living better. From a health perspective, this implies more significant economic and social investments to help more fragile people and the ones more likely to develop diseases. Despite this, it is impossible to think only in terms of "illness-less" to make people feel good and promote well-being. Therefore, it is also important to promote those factors that stimulate optimal ageing, which concern not only treating diseases but also preventing diseases and decline. The current cohort of elderly expects to be well-aged compared to the previous generation and to maintain their general well-being and quality of life longer. Some people aged 65 and more believe they are successfully "ageing well"; others, but less compared to past, rate as high their chances of becoming housebound, losing their memory or entering a nursing home (Bowling, 2011). Since older adults represent such a large proportion of the population, psychology should focus on how to change the status quo, move to what makes them grow well, and describe the changes in life span and what differentiates healthy ageing from pathological ageing.

1.3. Successful ageing as a new paradigm in ageing research

In the last decades in ageing and psychology, the word ageing has been frequently associated with success. The concept of successful ageing was used for the first time by Rowe and Kahn (1987), who stated:

"Research in ageing has emphasized average age-related losses and neglected the substantial heterogeneity of older persons. The effects of the ageing process have been exaggerated, and the modifying effects of diet, exercise, personal habits, and psychosocial factors are underestimated. Within the category of normal ageing, a distinction can be made between usual ageing, in which extrinsic factors heighten the effects of ageing alone, and successful ageing, in which extrinsic factors play a neutral or positive role. Research on the risks associated with usual ageing and strategies to modify them should help elucidate how a transition from usual to successful ageing can be facilitated" (p. 143).

As I mentioned in the previous paragraph, the focus on what differentiates healthy, or normal, from ill led to the total neglect of the complexity, heterogeneity of the elderly portion of the population and their individual differences. The methodological risk is to consider normal what is usual or in the average, losing potentiality and risk of people who are not, or not yet, ill.

Since Rowe and Kahn's definition, successful ageing has been studied and considered as a multidimensional concept taking different names and definitions such as ageing well, active ageing and productive ageing. However, the main objective in the field of successful ageing is how to extend both healthy and functional year in a life span perspective (Urtamo et al., 2019; Fries, 1980). The definition of Rowe and Kahn is based on the biomedical aspects such as longevity, the absence of disease and disability as they are factors that can promote ageing well. As illustrated in Figure 1.4, the dimensions that can contribute to successful ageing are based on subjective and objective aspects, which can be considered under the biomedical aspects (general health, physical function and condition and cognitive function) and psychosocial factors (good adaptation to the process of ageing and engagement in life).

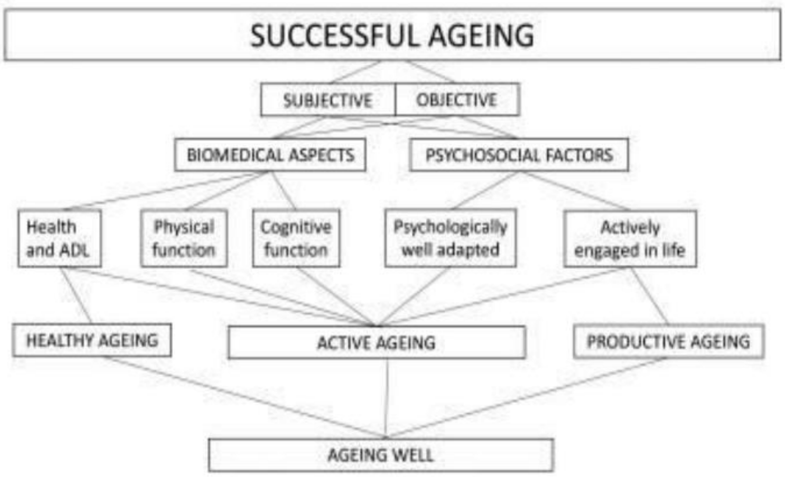

Figure 1.4. The dimensions of successful ageing in Urtamo et al. (2019).

The identification of four principles that may contribute to successful ageing has been described in a meta-analysis conducted by Kim and Park (2016). Authors identified the four aspects of successful ageing: avoiding disease and disability (as the original definition of Rowe and Kahn), having a high cognitive, mental, and physical functioning, actively engaging in life, and being psychologically well adapted in later life.

Avoiding disease and disability seems to be not as relevant in the current research as it used to be in the past: people with chronic diseases could also age successfully (Baltes and Baltes, 1990; Nosraty et al., 2015; Pruchno et al., 2015). The cognitive functions' domain seems to be the most relevant. Likewise, considering the psychosocial aspects is relevant too. Thus, considering the individual in a biopsychosocial perspective, cognitive aspects, social relationship and attitudes toward ageing are essential and contribute to the well-being of the individual. Maintaining cognitive abilities and preventing memory disorders are the main goals in old age (Hartley et al., 2018). The compensatory mechanism on the functional activity and the cognitive reserve (Stern, 2012) are the aspects that could explain the differences in terms of successful ageing among individuals in later life. Among psychosocial factors it has been underlined how being psychological well adapted in later life could contribute to successful ageing. Specifically, the dimensions to be considered should relate to life satisfaction, purpose in life perception of ageing.

These three aspects have been considered as a common thread in this thesis project. Alongside this multidimensional framework, in the last decades there has been much interest on the topic of active ageing in the political and welfare context. The exponential ageing of the population and its consequence on social and economic life has conducted the World Health Organization (WHO) to increase and promote politics toward active ageing (2002 In WHO official document, active ageing is defined as. "the process of optimizing opportunities for health, participation and security to enhance the quality of life as people age". The parallelism and influence of the principles and dimensions of successful ageing are explicit. The active ageing policy framework outlines six sets of variables or determinants that could affect active ageing throughout the life span (Swift et al., 2017):

1. Economic conditions (income, social security, opportunities for employment);
2. Health and social services (preventing disease, ensuring access to health services and continuous care);

3. Behaviour (healthy behaviour in life, for instance, promoting regular physical activity, diet and healthy eating and normal behaviour like avoidance of smoking and excessive alcohol);
4. Personal characteristics (the combination of biological, psychological and genetic factors);
5. Social situation (social support, proper education and literacy, and freedom from violence and abuse;
6. Physical environment (living in safe environments, clean, secure, and tailor-made).

These six determinants affect the three critical aspects of active ageing:

1. autonomy, freedom of choice, and the perceived ability to control cope with, and making personal decisions;
2. independence, the ability to conduct functional actions related to daily living with little to no help from others;
3. quality of life.

Since 2002, the active ageing policy framework influences global and European decisions in politics, economics, and welfare decisions.

1.4. Well-being in healthy ageing

Research in successful ageing and political and economic commitment on active ageing can contribute significantly to well-being in ageing. However, it is important also to consider the social representation of ageing and its impact on well-being.

In 2017, Swift proposed the Risk of Ageism Model (RAM). The author stated that ageism and negative attitudes toward ageing could negatively affect the active ageing framework, specifically in autonomy, independence, and quality of life.

Ageism is defined as stereotypes, prejudice, or discriminations against people because of their chronological age (Ayalon, 2017). In contrast to other forms of "ism", such as racism and sexism, everyone who lives longer could experience ageism in their life. There are several psychological explanations for why ageism arises. For example, the self-categorization theory suggests that age-based stereotyping and differentiation reflect a psychologically "sensible" use of age category boundaries to organize expectations about who does and does not share one's views, interests and identity (Turner et al., 1987). This includes the tendency to see older people as a homogenous group (Brewer, Dull, and Lui, 1981). Social identity theory further suggests that younger people are motivated to gain positive distinctiveness from older out-groups by asserting higher status and more valued characteristics for younger people (Tajfel and Turner, 1979). Intergroup threat theory suggests that older people are perceived to threaten society by being a burden on healthcare and welfare resources (Stephan and Stephan, 2000). Alternatively, terror management theory suggests that age prejudices arise out of a fear of our mortality (Chonody and Teater, 2016; Greenberg, Schimel, and Martens, 2002).

The most common negative stereotypes related to older adults' competence are physical and cognitive functioning, which are assumed to decline with age (Fiske, Cuddy, Glick, and Xu, 2002; Lamont, Swift, and Abrams, 2015). Other commonly held perceptions are that older people lack creativity, they are unable to learn new skills, they are unproductive, a burden on family and society, and they are ill, frail, dependent, asexual, lonely and socially isolated (Hummert et al., 1994; Swift, et al., 2013). On the other hand, common positive stereotypes define older people as wise, generous, friendly, moral, experienced, loyal, and reliable (Hummert et al., 1994; Swift et al., 2013).

The first mechanism of the risk on the ageism model (RAM) can operate is via stereotype embodiment, which occurs when stereotypes that were once focused on "other" older people become applied and relevant to the self (Levy, 2009). We know that the young population tend to have a preference, implicit and explicit, for the same group of age: the age bias (Crockett and Hummert, 1987; Kite and Johnson, 1988; Perdue and Gurtman, 1990). Levy's (2009) stereotype embodiment theory proposes a model of how stereotypes and societal representations of old age are implicitly internalized over the lifespan, modifying self-perception of ageing (the attitudes and beliefs toward one's age). Moreover, the stereotype embodiment theory is more effective in how stereotypes are self-relevant when participants feel, in fact, "old" or in the context in which participants are more aware of their age.

The second mechanism is stereotype threat, which refers to the threat experienced by an individual when they feel a situation puts them at risk of confirming a negative stereotype about their group (Steele and Aronson, 1995; Carr and Steele, 2010). Age-based stereotype threat studies tend to employ between-participant experimental designs, which compare a threat condition (either fact-based or stereotype-based) with a baseline condition. For instance, Swift (2012) found that older people who were informed that their performance on a test would be compared with the younger individuals performed half as well on a grip strength test compared to the control group. This paradigm of manipulation and activation of the stereotype has also been replicated with cognitive performance (Abrams et al., 2008; Hess et al., 2003). The stereotype threat seems to be more effective in young-old (Hess et al., 2009) compared to older people. The final pathway is being a target of ageism itself. Moreover, the subjective flexibility of age categorization (Abrams et al., 2011; Kornadt and Rothermund, 2011) means that vulnerability to stereotype embodiment, stereotype threat and ageism is different among individuals and affect even people who do not perceive themselves as belonging to the old group.

Ageism and negative perception of ageing are a longitudinal pathway that have an impact in terms of elderly discrimination, of a future vision of oneself, and on the general well-being of the elderly (present and future). Therefore, with our research we aimed, if possible, at modifying attitudes and beliefs toward age stereotypes, older group and self-perception of ageing, with the help of virtual reality techniques.

"The reality that I hold for you lies in the form that you confer upon me, but it is reality to you and not to me; the reality that you hold for me lies in the form that I confer upon you, but it is reality to me and not to you; and for myself, I have no other reality than that which I succeed in conferring upon myself.
And how is that? Why, by building myself up, that is all."
— ***Luigi Pirandello, "One, None, and One Hundred Thousand***

2. A methodological issue: how can we measure age perception and attitudes? Suggestions from the digital world

Jang Ji-Sung, a Korean woman who lost her daughter in 2016, was the protagonist of a controversial documentary: "Meeting you". This documentary tells the "virtual" reunion between the mother and her child. The mother wears a virtual reality head-mounted display and perceives and interacts with this avatar with the deceased daughter's exact physical appearance. To make the interaction even more realistic, the avatar was able to speak with the same voice and phrases used by the daughter when she was alive, recombined with artificial intelligence systems.

The level of realism, sense of presence and high detail definition reached by virtual reality in recent years was not imaginable until a short time ago, as it is often the case with technological innovations. The potentiality and uses run faster than the ethical issues related to the use of the same. For instance, the possibility of seeing someone dear to us can always be a comforting palliative useful in the management of grief. On the other hand this aspect risks perpetuating the process of healthy grief itself, preventing the correct elaboration of dual processes. As underlined by Slater et al. (2020), virtual and augmented reality have great potential from a research point of view and wide commercial use. However, it is crucial to open a debate on the psychological and ethical implications of virtual reality, especially with the growth of hyper-realistic techniques that makes the virtual world, at times, indistinguishable from the real one.

On the one hand, the use of virtual reality technologies in research offers the possibility of simulating immersive and interactive real-life scenarios to produce a sensation of "being there" (Garcia-Betances et al., 2015). Virtual reality also offers the ability to perform tests in an adaptive environment that can be adjusted according to the needs of various patients to the needs of various patients (Riva, 1998; Optale et al., 2010).

Although it may appear safer and more ecological to use virtual reality techniques instead of other research methodologies, there are some risks related to their use. Behr and colleagues (2005) summarized the risks as follow:

· motion sickness

· information overload

· intensification of the experience

· cognitive, emotional and behavioral disturbances after re-entry into the real world.

Moreover, realism has reached a high definition, and virtual reality is not limited to research projects. Its diffusion starts to be cheaper and used at a commercial level for leisure activities such as immersive videogames (Wassom, 2014). Some literature underlines the necessity among researchers to debate the ethical implications and potential use of these technologies (e.g., Madary and Metzinger, 2016).

One of the aspects that interests our research the most is that virtual embodiment can lead to emotional, cognitive, and behavioural changes. Although studies in this field can benefit individuals and society (i.e., improving positive attitudes, reducing discrimination, increasing empathy), this technique can be used in a more harmful way. For instance, an individual can temporally use an avatar with "bad" intentions and behaviour. This can be true in videogames in which the protagonist has to kill somebody repeatedly. The effect on behaviour and attitudes should raise some questions, significantly whether the use can be prolonged and uncontrolled.

Virtual reality refers to a set of devices capable of generating a virtual environment similar to the real one and providing different experiences and opportunities (Chryssolouris et al., 2000), with different degrees of immersion and realism. Its uses are potentially endless. Several are, in fact, the virtual reality studies for the clinical treatment of phobias (Garcia-Palacios et al., 2002), for the treatment of PTSD (Rothbaum et al., 2001; Difede et al., 2007), for investigating body representation in obesity (Scarpina et al., 2019) and for the cognitive rehabilitation of patients (Dockx et al., 2016; Laver et al., 2011).

One main achievement of VR is the experience of living as another person. Through virtual reality, people can virtually use another person's body, somebody belonging to another social group. An in-group member can temporally occupy the body of another "outgroup" member (Slater et al., 2020). This makes it possible to the body of another ethnicity (Maister et al., 2013; Peck et al., 2013; Banakou et al., 2016), another age, for instance, an adult could choose to be in a child's virtual body and vice versa (Banakou et al., 2013; Tajadura-Jiménez et al., 2017), or one could modify some body characteristics such as a tall person can be shorter and vice versa (Yee and Bailenson, 2007; Freeman et al., 2013).

The effect of digital representation on self-representation has been described as the *Proteus effect* by Yee and Bailenson (2007, 2009). There are two possible explanations of this effect that are not specific to virtual reality but refer to the digital doppelgänger. One possible explanatory framework is "behavioural confirmation", the process where one person's expectations influence another person’s behaviour who finally behave to align it with the expectations of other significant (Snyder, Tanke, and Berscheid, 1977).

Since this effect is not specific to virtual social interaction, Yee and Bailenson (2007) argued that self-perception theory might explain better the Proteus effect: people infer their attitudes and beliefs from observing themselves as if from a third person’s point of view (Bem, 1972).

Moreover, embodied theory opens up new methodologies and applications in virtual reality and the study of attitudes and behaviours. Embodied cognition theories propose extensive evidence on the relationship between sensory, motor functioning and cognition (Glenberg et al., 2013). For instance, Maguinness et al. (2013) observed that the estimation of weight in healthy elderly is less accurate than young adults. This effect of ageing can be partly explained in terms of motor simulation: the loss of strength in ageing, real or perceived, might lead to increase difficulties lifting objects, leading, therefore, to an overestimation of their weight. Other studies found that body perception can influence cognition (Casasanto, 2011; Osiurak et al., 2014). Body posture, for instance, can influence autobiographical retrieval in both young and older adults (Dijkstra et al., 2007).

Since we are interested in the impact of attitudes and behaviour on the ageing process, virtual reality and embodiment offer innovative methodological solutions to study ageism and perception of ageing in both young adults and the elderly. To do so, we decided to focus on multisensorial integration (i.e., visuo-tactile stimulation) and avatar characteristics.

As we mentioned before, some studies aimed at investigating the impact of "virtually being someone else" and studying behaviour and attitudes in participants after paradigm manipulation. Interestingly, in the field of -ism, for instance, a study by Peck et al. (2013) was able to reduce implicit racial bias by embodying participant in different skin colour avatars. Similarly, in a study by Banakou (2018), participants were embodied in avatars representing stereotypically high intelligence (i.e., by embodying Albert Einstein avatar). They combined first perspective view with a head-mounted display (when in a virtual reality environment, participants see their virtual body while looking at their real body) and visuomotor stimulation (a full-body ownership illusion technique, in which movement and visual feedback of the avatar are synchronous with the participant’s movement). Impressively, participants improved their implicit attitudes towards older people (i.e. reducing the age bias) and performed better at cognitive tasks. This study results suggest a possible implication of full embodiment of different avatar as able to act not only at the perceptive or behavioural level but also at the cognitive level.

How does the process of embodiment illusion work?

The first work on multisensorial integration comes from the well-known rubber-hand-illusion paradigm (Botvinick and Cohen, 1998). In this paradigm, a fake hand near the participant's real hand is touched synchronously with the real hand. However, the real hand is covered and it is possible to see only the touch on the fake hand while feeling the touch on the participant’s hand. This illusion pushes the participant to believe that the fake hand belongs to him/her. This famous illusion has also been replicated in virtual reality, where the fake hand is, in fact, a digital hand (Ijsselsteijn et al., 2006; Slater et al., 2008). This illusion can be extended to the full body, inducing a virtual body ownership illusion. The virtual bodies are represented or recreated generally with avatars' bodies (Waltermate et al., 2018).

Which factor can contribute to increasing the virtual body ownership illusion?

It can be promoted or triggered in different ways by combining bottom-up and top-down factors.

Bottom-up factors are those related to the multisensory integration and combine synchronous input from sensorial and motor system (e.g. visual, motor, tactile, proprioceptive). Examples are:

1. First-person perspective: a full-body ownership illusion allows participants to look at their own body and see the virtual one in the same anatomical position. However, Debarba et al. (2015) did not find significant differences between first-person and third-person perspectives (a condition in which participants can control the body without an anatomical overlap). They suggest that it is the visuomotor illusion to induce a stronger body ownership illusion.
2. Synchronous visuo-tactile stimulations: as mentioned for the rubber hand illusion paradigm, the illusion is perpetuated by the temporally synchronously touch and anatomical overlapping of the body in the virtual body. Usually, the participant looks at his/her virtual body part while he/she is touched over his/her real body part. Commonly, it is used for upper or lower limbs. This technique's advantages are that a head-mounted display reproducing either a video or a virtual reality scenario is enough to create the illusion.
3. Synchronous visuomotor stimulation: as cited in the works of Peck et al. (2013) and Banakou (2018), the illusion is elicited by the synchronous movement of the avatar with the participant's real body. This technique is possible only through

sensible capture of the participant's body that allows tracking the participant's position during the interaction in the virtual scenario.

Top-down factors are those related to the similarity of form and appearance of the virtual body compared to the real one (Tsakiris and Haggard, 2005; Lugrin et al., 2015). However, the top-down factors such as anthropomorphism or realism on the body illusion are not as evident as the bottom-up factors. Lugrin et al. (2015) found that virtual body ownership in the case of human resemblance is not so different from the one of a robot or cartoon figure. Nevertheless, avatar body characteristics are fundamental for representing the social group, especially in the paradigm that investigates attitudes toward a social group.

Further studies should investigate the influence of some avatar characteristics on embodiment illusion strength and attitudes modification effect. In the following chapter, we will discuss two studies concerning virtual reality methodologies that could help study age perception and attitudes. The first experimental study has been conducted with a classic visuo-tactile paradigm with a head-mounted display; we investigated how age bias change before and after the multisensorial manipulation in three age groups: young adults, adults and young olders.

In the second study, I will present preliminary analysis and data on the building and creation of an avatar dataset that could be used for future research to study social interaction, attitudes, and behaviour toward the elderly and even self-perception of ageing in young adults. This second study has been conducted in collaboration with the Institute of Psychology of Paris under the supervision of prof. Pascale Piolino.

3. STUDY 1 "NO COUNTRY FOR OLD MEN: REDUCING AGE BIAS THROUGH VIRTUAL EMBODIMENT"[a]

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[a]This study (only young adults data) has been recently accepted for the publication in the Annual Review of Cybertherapy and Telemedicine

Abstract. Ageism is a negative attitude toward aging and elderly people. Many studies have investigated the effects of ageist attitudes and age stereotypes, but little is known about their ability to be modified. By making young and older adult participants embody arms of older individuals, we attempted to induce the illusion of ownership for the virtual body part and therefore reduce the negative implicit bias towards elderly people. Young adults (20-30 years old), adults (50-60) and older adults (70-80) were assessed for explicit (Fraboni Ageism Scale) and implicit (Age-IAT) attitudes toward the elderly. Then, through videos of arms touched in virtual reality and a synchronous real tactile stimulation, we elicited an illusion of body ownership. Participants looked at their "virtual" arm while they were touched by the same wooden stick seen in the video, every second for two minutes. After each condition, Age-IAT was re-administered. The results suggest a decrease in negative attitudes toward elderly people in the adult population and a similar pattern in life span.

Keywords. Virtual reality, Embodiment, Ageism

3.1. Introduction

Ageism is a negative attitude toward ageing and older adults. Many studies have investigated the effects of ageist attitudes and age stereotypes on the behaviour of others towards older people and the self-related beliefs and behaviour of older adults themselves (Giasson et al., 2017). The explicit form of ageism is defined as a conscious alteration in feelings, behaviors and thoughts dependent on the person's age; alternatively, implicit ageism defines an automatic and unaware process of prejudice (Levy et al., 2002).

The direction of this process is mostly from the young towards the elderly but, in some cases, it also applies in the opposite direction. Levy et al. (2000) demonstrated that implicit stereotypes on elderly can influence how older people perceive themselves and other older individuals. Most dramatically, adults aged 60 and older showed a pro-young effect of similar magnitude to adults in their twenties, despite changes in explicit age preferences (Nosek et al., 2007).

In fact, it seems that younger and older population do not differ in attitudes toward age. A developmental explanation posits that with passing time age schemas and categories are more elaborate and differentiate but retain core elements. Moreover, older persons have more complex view of aging than do younger people, although is not necessary more positive (Hummert et al., 1994). On the other hand, other studies suggest more positive attitudes of elderly toward older group, compared to the young adults, in line with the social identity theory and the in-group bias (Tajfel and Turner, 1979). These findings may depend on the measure of age attitudes, explicit versus implicit: whereas the explicit measure is associated with a more aware in-group activation, the implicit measure may show the core attitudes of both young and elderly (Hummert et al., 2002).

Virtual reality is not only a powerful tool that can provide new insights into social cognition and stereotype issues, but it is also an instrument able to induce a change and provide simple measurements. In recent years, virtual reality has been used for motor and cognitive rehabilitation, neuropsychological evaluation and embodiment induction. Indeed, there is mounting evidence that virtual reality techniques allow a strong illusion of ownership over a virtual body to be produced (Ehrsson et al., 2008). This in turn provides a methodology to study social cognition and attitudes toward self and others. Moreover, by integrating social cues, such as voice or body characteristics in a virtual environment, it is possible to change consolidated perceptions and beliefs. Some evidence suggests that “virtual” alteration of the skin reduces implicit racial bias (Peck et al., 2013) and alteration of age in an older adult population can reduce negative stereotypes towards the elderly (Yee et al., 2007).

Most of the studies on attitudes and virtual reality are based on perspective-taking techniques: taking a different perspective of another social group can reduce stereotypes with respect to that outgroup (Galinsky and Moskowitz, 2000). Furthermore, body changes can be applied to higher levels of cognitive processing rather than only perceptual and motor response. For instance, Banakou (2018) found that people embodied in avatar culturally associated with high cognitive abilities (i.e., Einstein) lead to higher performance.

Since ageism is a common daily issue in contemporary society, we firmly believe that this kind of methodology could help in studying the effect of an older body on the stereotypes and attitudes of a young population. Based on this goal, this study can be regarded as a first step towards investigating the role of own-body appearance in implicit attitudes of ageism.

Our aim was to induce body-illusion ownership and thus reduce the negative implicit bias toward older adults in young adults and investigate whether the same implicit attitudes would be found in older group. Our expectation was that the effect would be present exclusively in the older arm condition and not in the same-age arm condition, only in the embodiment condition (i.e. anatomical position). Moreover, we conducted a second study to investigate the same implicit age bias in two groups of older adults, to verify the persistence of implicit age bias during life span and whether virtual reality could be a sound methodology to study embodiment and attitudes modification in all ages.

3.2. Method

3.2.1. Sample

For the young adult sample, 24 participants (12 males, mean age: 23.75±2.308) took part in the experiment. They were all Italian speakers and had no history of psychiatric or neuropsychological disorders. All participants were students at the University of Milano-Bicocca. The project was approved by the Ethics Committee of the University of Milano-Bicocca and conducted in accordance with the 2013 Declaration of Helsinki. We aimed to recruit the same sample size for adults (50-60 years old) and older adults (70-80 years old). The number of participants was determined a priori in order to design a properly powered reaction with repeated measure and ANOVA analysis (effect size 0.25).

Nevertheless, due to the COVID pandemic it was not feasible to reach the expected statistical sample for the adult adults and the older adults. Eventually, for the adult adults we recruited 13 participants (mean age 55,92± 3,043, 4 males) and 15 older adults (74,67± 2,439, 8 males).

3.2.2. Experimental Design

We used a within-group design. Each participant completed 4 conditions obtained by crossing two different arm AGE conditions (young arm and old arm) and two different arm POSITION (anatomical and non-anatomical). We expected to reach the hand ownership illusion just in the anatomical condition, since a non-spatial overlapping between the real hand and the virtual hand should break the sensorimotor integration.

3.2.3. Stimuli

Videos for virtual reality were recorded with a Samsung Gear 360® in the laboratory of the Psychology Department of Milano-Bicocca. The recorded arms belonged to two different real males. For the young arm sessions (Fig. 3.1), we tapped a 30-year-old's hand with a wooden stick every second for 120 seconds. The arm was extended in front of the participant perpendicular to the lateral axis.

For the old arm sessions (Fig. 3.2), we used the same procedure by tapping a 60-year-old's hand. The experimenter, who tapped the hand in the virtual and in the physical reality, was the same. We used two conditions as controls in which the VR-videos were left 45 degrees calibrated (i.e., the arm had a non-anatomical position) in order to avoid spatial overlapping between proprioceptive and visual inputs.

Figure 3.1. Anatomical -Young hand condition.

Figure 3.2. Anatomical - Old hand condition.

3.3. Measures

3.3.1. Embodiment Scale

It is a questionnaire adapted from previous studies conducted to evaluate body illusions (Tosi et al., 2018). It measures the sense of the embodiment through 15 statements to evaluate on a 7-point Likert scale. We calculated Embodiment Score by adding the three scores of the Ownership, Agency and Location statements (Longo et al., 2008). Ownership is related to the feeling that the virtual hand is part of the participant's body, the feeling of looking directly at hi/her arm and that the virtual hand taking on the characteristics of the participant's real hand. Locations are related to the feeling that the virtual hand and the real hand are in the same place. Agency is related to the feeling of control over the real hand and being able to move it. We obtained a single score for each condition (young hand-anatomical, old hand- anatomical, young hand non-anatomical and old hand-non anatomical).

3.3.2. Fraboni Ageism Scale (FSA)

It measures both affective and cognitive components of explicit ageism, based on Butler's definition (Fraboni et al., 1990). In fact, Butler defined "ageism" as a combination of three connected elements: prejudicial attitudes toward older people, the old age and the aging process itself; discriminatory practices against older people and institutional practices and policies that perpetuate stereotypes against the elderly (Wilkinson and Ferraro, 2002). The Italian version of the Fraboni Ageism Scale (Donizzetti et al., 2019) consists of 19 statements to evaluate on a 4-point Likert scale ("1" strongly disagree to "4" strongly agree). It is composed of three subscales: separation and avoidance (six items, e.g., "it is best that old people live where they won't bother anyone"), stereotypes and antilocution (eight items, e.g., "many old people just live in the past"), affective attitudes and discrimination (five items, e.g., "the company of most old people is quite enjoyable"). Items of the last dimension are reverse keyed). Higher scores indicate higher levels of explicit ageism. The internal consistency reliability of the scale is 0.76 Cronbach's α.

3.3.3. Age-Implicit Association Task

This is a widely used cognitive-behavioral test that measures the strength of automatic implicit associations relying on reaction time in a sorting task. Differently from explicit measure (i.e., Fraboni Ageism Scale), the implicit association test assesses indirectly attitudes and stereotypes toward the elderly by collecting response latencies to category judgement tasks (Hummert et al., 2002). The age-IAT measures the bias by requiring people quickly to categorize photographs of faces (young and old) and words (positive or negative) into groups. Implicit bias is calculated from the differences in speed and accuracy between categorizing young faces/positive words and old faces/negative words, *compared to old faces/positive words and young faces/negative words. Higher values of IAT is* interpreted as a greater age bias, or a preference for young faces compared to old faces. A growing body of research attests the reliability (internal and test-retest) and validity (convergent, discriminant and predictive) of the IAT as a measure of strength of implicit attitudes and stereotypes distinct from explicit measure of the same constructs (see Greenwald and Nosek, 2001, for a review).

We administered the Age-IAT using Inquisit 4.0. Software, which allowed us to calculate d-scores (Greenwald et al., 2003), standardized mean difference scores of the hypothesis-inconsistent pairings (Young-Bad/Old-Good) and hypothesis-consistent pairing (Young-Good/Old-Bad).

3.4. Procedure

Firstly, the participants completed the questionnaire (FSA) and performed the test (pre-IAT), providing an explicit and an implicit measure of ageism. For each session, they watched a video with tapping on the arm (2 min, 1 touch/sec) in virtual reality, and then completed the Embodiment Questionnaire Scale, providing a self-reported measure of embodiment and IAT (5 min). The participants wore an Oculus Gear VR headset and were instructed to look in the real arm direction, extended in front of them perpendicular to the lateral axis.

Older adults were administered also with the Revised version of the Addenbrooke's Cognitive Examination (ACE-R; Mioshi et al., 2006) to assess global cognitive functioning and the Geriatric Depression Scale (GDS; Yesevage et al., 1982) for a global neuropsychiatric assessment.

3.5. Results Young adults

3.5.1. Embodiment Measure

Analyses were conducted with R Studio. We conducted a Repeated Measure ANOVA with Embodiment score (calculated as the mean of the three subdimensions) as the dependent variable and AGE (old hand vs. young hand) and POSITION (anatomical vs. non-anatomical) as factors. We found a main effect of POSITION ($F(1,23) = 30.68632$, $p<0.0001$, $\eta^2 = 0.572$). As we expected, we found a stronger full body illusion in the anatomical position compared to the non-anatomical condition (Fig. 3.3; **Tab. 3.1**).

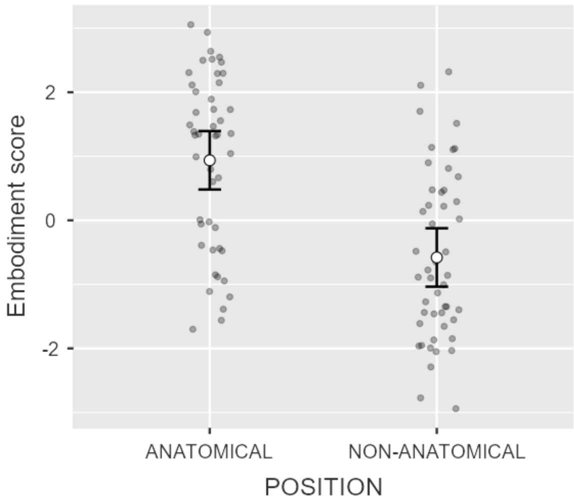

Figure 3.3 Mean score of Embodiment scale for POSITION (anatomical vs. non-anatomical)

Table 3.1. Estimated Marginal Means of the Embodiment Questionnaire scores.

Position	MEAN	SE	95% CI LOW	95% CI UP
Anatomical	0.937	0.226	0.481	1.394
Non-anatomical	-0.580	0.226	-1.036	-0.124

3.5.2. Fraboni Ageism Scale

We conducted a Repeated Measure ANOVA with the scores to each subscale of FAS as dependent variable. We found a main difference between subscales ($F(2,46) = 20.5$, $p<0.0001$, $\eta^2 = 0.471$). We applied Post-Hoc comparisons between the subscales with Bonferroni correction. The avoidance subscale shows a lower score compared to stereotypes and antilocution ($p<0.0001$) and affective attitudes and discrimination ($p<0.0001$) (see Fig. 3.4 and Table 3.2).

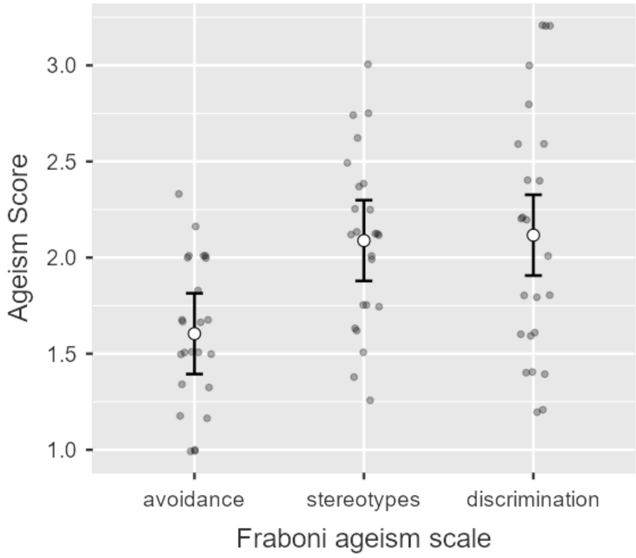

Figure 3.4 Mean score of Fraboni Ageism scale for each subdimension (avoidance, stereotypes, discrimination)

Table 3.2 Estimated Marginal Means of FSA subscales.

FRABONI SCALE	MEAN	SE	95% CI LOW	95% CI UP
Avoidance	1.60	0.104	1.39	1.81
Stereotypes	2.09	0.104	1.88	2.30
Discrimination	2.12	0.104	1.91	2.33

3.5.3. Implicit Ageism

Our interest focused on the difference between the post-IAT for each condition and pre-IAT (i.e., ΔIAT= pre IAT– post IAT). Our hypothesis was that the mean ΔIAT would show a greater increase for the participants in the old anatomical condition than in the other conditions, where a greater ΔIAT suggests a positive decrease in negative attitudes toward elderly people. The IAT score is calculated as d-score (standardized mean difference score of the 'hypothesis-inconsistent' pairings and 'hypothesis-consistent' pairings). Positive d-scores support a stronger association between 'Young-Good' and 'Old-Bad' than for the opposite pairings. ΔIAT is the difference between the d-score of the baseline condition and the d-score of each condition.

We conducted a Repeated Measure ANOVA with ΔIAT values as the dependent variable and AGE (old hand vs. young hand) and POSITION (anatomical vs. non-anatomical) as factors. We found a main effect of AGE ($F(1,23) = 9.013$, $p<0.01$, $\eta^2 = 0.282$), but no interaction effect. (see Fig. 3.5 and Table 3.3)

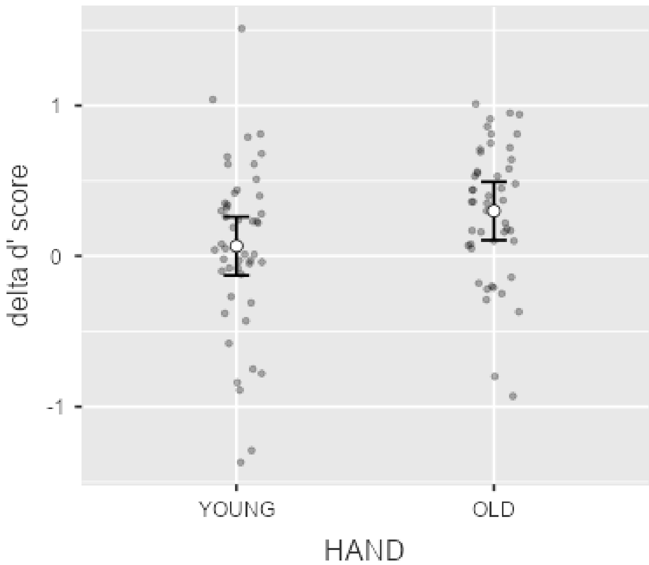

Figure 5.5 Mean score ΔIAT (d-score baseline - dscore conditon) in AGE (old hand vs. young hand)

Table 3.3 Estimated Marginal Means of ΔIAT values

CONDITION	MEAN	SE	95% CI LOW	95% CI UP
Young Hand	0.066	0.095	-0.128	0.261
Old Hand	0.299	0.095	0.105	0.493

3.6. Results Older adults

Due to the reduced extent of the two group's sample, we decided to conduct the analyses with the two group of age together in order to estimate a possible effect and the feasibility of the methodology. However, future data collection will allow testing our hypothesis: Do implicit attitudes remain unchanged in life span? Is it possible to improve negative age bias even in older adults?

3.6.1. Embodiment Measure

Analyses were conducted with R Studio. We conducted a Repeated Measure ANOVA with Embodiment score (calculated as the mean of the three subdimensions) as the dependent variable, AGE (old hand vs. young hand) and POSITION (anatomical vs. non-anatomical) as factors and PARTICIPANTS' AGE as covariate. We found a main effect of POSITION ($F(1,27) = 41.1054$, $p<0.0001$, $\eta^2 = 0.604$). As we expected, we found a stronger full body illusion in the experimental conditions compared to the control conditions (anatomical vs. non anatomical) (see Fig. 3.6 and Table 3.4).

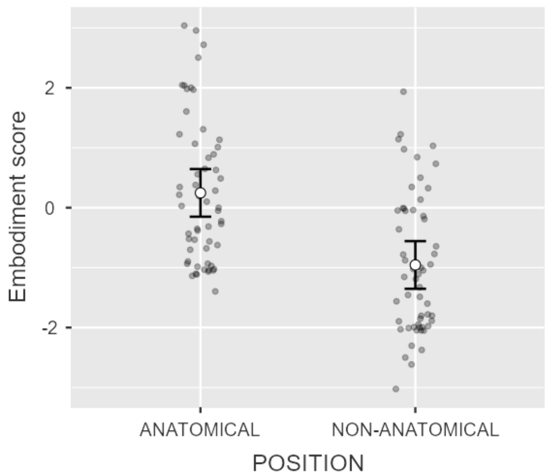

Figure 3.6 Mean score of Embodiment scale for POSITION (anatomical vs. non-anatomical)

Table 3.4 Estimated Marginal Means of the Embodiment Questionnaire scores.

CONDITION	MEAN	SE	95% CI LOW	95% CI UP
Anatomical	0.247	0.197	-0.151	0.645
Non-anatomical	-0.955	0.197	-1.353	-0.558

3.6.2. Fraboni Ageism Scale

We conducted a Repeated Measure ANOVA with the subscales of FAS scores as dependent variable. We found a main difference between subscales ($F(2,52) = 28.204$, $p<0.0001$, $\eta^2 = 0.520$). We applied Post-Hoc comparisons between the subscales with Bonferroni correction. The avoidance subscale shows a lower score compared to stereotypes ($p<0.0001$) and discrimination ($p<0.0001$) (see Fig. 3.7 and Table 3.5)

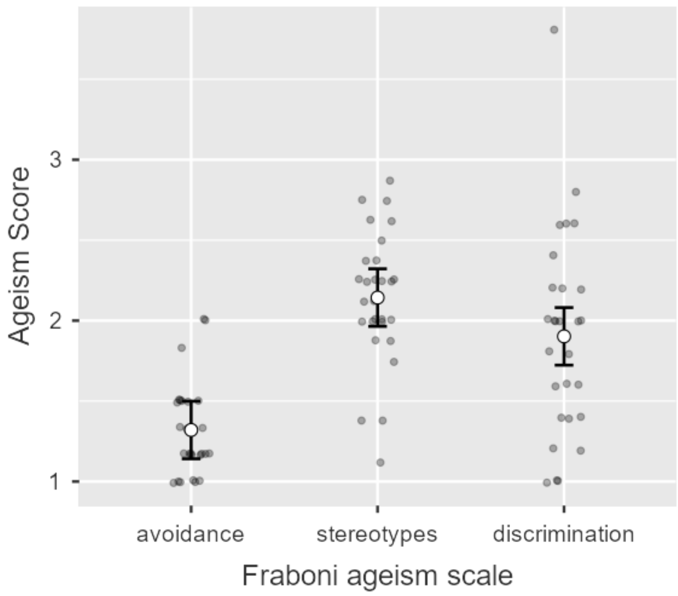

Figure 3.7 Mean score of Ageism scale for each subdimension (avoidance, steoretypes, discrimination)

Table 3.5 Estimated Marginal Means of FSA subscales.

FRABONI SCALE	MEAN	SE	95% CI LOW	95% CI UP
Avoidance	1.32	0.104	1.39	1.81
Stereotypes	2.14	0.104	1.88	2.30
Discrimination	1.90	0.104	1.91	2.33

3.6.3. Implicit Ageism

We conducted a Repeated Measure ANOVA with ΔIAT values as the dependent variable, AGE (old hand vs. young hand) and POSITION (anatomical vs. non-anatomical) as factors and PARTICIPANTS AGE as covariate. We did not find any significant effect.

3.7. Difference between young adults and older adults in implicit and explicit attitudes

Even though this data should be interpreted carefully, due to age distribution of the sample, they may suggest a possible direction for future analysis. Specifically, we are interested in investigating whether and how implicit and explicit measures of ageism change during life span.

In order to do this, we analyse the level of Fraboni Ageism Scale subdimensions and the d' score of baseline IAT in the two groups (young adults vs other age).

Interestingly, results show a trend to a significant effect ($F(2, 100)=3.00$, $p=O.0545$, $\eta^2=0.057$), with a slighter intensity of avoidance attitudes of older age compare to younger population. Nevertheless the implicit attitudes (d' score of IAT baseline, higher the score higher the age bias) seem not to differ among ages ($F(1, 43) =1.03$, $p=0.315$).

3.8. Conclusion

The purpose of this study was to investigate attitudes toward aging and the possibility of temporarily changing attitudes and stereotypes. Only a few other studies have, to our knowledge, found changes in age attitudes in virtual embodiment. Nevertheless, this is the first study that has used visuo-tactile stimulation to investigate changes in social attitudes. Firstly, according to previous studies on ageism, our data on young adults show high stereotypes and discrimination traits in behaviour towards the elderly.

Moreover, as we expected, the embodiment scores were consistent with the experimental condition: when the real-arm position was spatially coherent with that of the virtual arm, a higher full body illusion was reached. Interestingly, implicit age bias was modified only after old arm exposure, independently from arm position and embodiment condition. The data are consistent with a previous study on social cognition in which exposure to a stereotypic exemplar reduces implicit prejudice (Dasgupta and Rivera, 2008).

Furthermore, according to the Proteus Effect, a phenomenon in which participants change attitudes and behaviour according to their digital avatar (Yee and Bailenson, 2007), changes in attitudes do not require strong full-body ownership and the non-anatomical condition could induce an embodiment which is reduced but still present. However, the results do not enable us to determine the duration of the effect following our manipulation. Future studies could address the issue regarding the specific embodiment effect on attitudes by manipulating the long-term effect.

Despite the small sample size, it seems that the same illusion can be elicited also in older adults. However, a larger sample size will allow us to determine whether the exposure to the older hand or younger hand can elicit a modification in the implicit attitudes.

Nevertheless, according to Hummert (2002) young and older adults share some characteristic of explicit ageism during life span (i.e. avoidance feeling and behaviours) probably due to in-group identification (Tajfel and Turner, 1979), but not implicit age bias.

To summarize, the study has shown that a visuo-tactile stimulation in Virtual reality could be a valid method of inducing an old body-illusion ownership. Future studies will be aimed at investigating this effect in elderly people and whether inducing younger body-illusion ownership could positively increase one's own self-perception of aging (how participants perceive their own age process).

3.9. Supplementary materials

Embodiment questionnaire

-3	-2	-1	0	1	2	3
Totalmente in disaccordo			Né in accordo né in disaccordo			Totalmente d'accordo

		Position	
	DOMANDA/CONDIZIONE	Anatomical	Non-anatomical
Ownership	Q1. Ti sembrava di guardare direttamente le tua mano sinistra?		
	Q2. Ti sembrava che la mano presente nei visori ti appartenesse?		
Agency	Q3. Ti sembrava di poter muovere la mano presente nei visori?		
	Q4. Ti sembrava di non poter controllare la mano presente nei visori?		
Location	Q5. Ti sembrava che la mano presente nei visori fosse nella stessa posizione della tua?		
	Q6. Ti sembrava di percepire il tocco dato alla mano presente nei visori?		
Loss of own legs	*Q7. Ti sembrava che la tua mano sinistra fosse sparita?*		
	Q8. Ti sembrava che avresti potuto muovere tua mano sinistra se avessi voluto?		
	Q9. Ti *sembrava che la tua mano sinistra fosse fuori dal tuo controllo?*		
	Q10. Ti *sembrava di non sapere dove si trovasse realmente la tua mano sinistra?*		
Deafference	Q11. Hai avuto la sensazione che la tua mano sinistra fosse intorpidita?		
Control	Q12. Ti sembrava che il tuo corpo stesse diventando "artificiale"?		
	Q13. Ti sembrava di avere tre mani?		
Affect	Q14. Hai trovato quest'esperienza piacevole?		
Age	Q15. Quanto ti sembrava che l'età della mano nei visori fosse simile alla tua?		

4. STUDY 2 “PANDORA”: A NEW DATABASE OF YOUNG AND OLD AVATAR”

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Abstract Embodied cognition research has rapidly increased in the last years. Considering the importance of avatar characteristics in inducing the complete full-body illusion is essential to control some psychological measures in creating and using avatars. Aim of the current study was to reach a first step validation of an young and old avatar database, by adapting photos selected from Chicago Face Database to VR environment with Character Creator 3 (i.e., a software that enable to customize and easily create new realistic avatar). Twenty-eight bodies and fifty-four 3D faces have been rated for many psychological measures (i.e., attractiveness, realism, trustworthiness and ownership) by Italian young and old individuals. Moreover we aimed to verify the procedure of Head Shot Plug-In in creating virtual avatar as similar as possible to the real one. The database, as well as the creation process, can be applied in virtual reality research, mainly in the field of embodied cognition.

Keywords *Virtual reality, Avatar, Aging*

4.1. Introduction

When we interact in the virtual world, we need a digital body. Avatars are not only a means to interact with the virtual environments but also an extension of our body, and the characteristics of the avatar could influence the embodiment experience (Tsakiris and Haggard, 2005; Lugrin et al., 2015) as much as perception, attitudes and cognition (Peck et al., 2013; Banakou et al., 2018).

The illusion of body ownership, indeed, leads to modification in behaviour and attitudes and has a psychological effect on users in controlling the avatars. Therefore, avatar characteristics and in-group belonging are relevant in virtual reality paradigm, especially to study the impact of some psychological aspect on social cognition and cognitive functions.

The Illusion of Virtual Body Ownership (IVBO) builds upon the effect that users feel artificial body parts to be their own. A first-person perspective of the user in an immersive VR setting triggers strong IVBO effects even though the virtual body differs considerably from the real person's body. One's bodily self-perception can be temporarily shifted towards the virtual body of an avatar with a different gender age, race, body shape, longer limbs, and even having a different posture.

In a study, Fribourg et al. (2020) investigated the impact of avatar characteristics on sense-of-embodiment dimensions. As described by Kilteni et al. (2012), the sense of embodiment in virtual reality refers to the feeling of being inside, controlling and having a virtual body. These factors can be associated to the sub-dimensions: self-location, sense of agency and ownership, respectively. Fribourg et al. (2020) found that appearance of the avatar is considered less important than control over the body (agency) and point of view (location) to reach a complete embodiment illusion, although the authors underlined that it may depend on the task performed. Nevertheless, another study of Waltermate and colleagues (2018) demonstrated how personalized avatars significantly increase body ownership and sense of presence.

Therefore, avatar body characteristics are fundamental for experiments with virtual reality and, even if many virtual user's alter ego has been used, there is any validated avatar database, which considers psychological and social suitability for experiments in human science. Furthermore, the elderly population is the least represented category in the digital world and, when represented, it is often stereotyped.

In addition, there are few studies concerning avatar and age characteristics, most focusing on the relation with body image (Cacioli et al., 2014; Park et al., 2018; Keizer et al., 2016; Corno et al., 2018) or uncanny valley (Shin et al., 2019; Katsiri et al., 2015).

Aim of this research was to create an extensive avatar database of bodies and avatar identities, checked for some psychological measures, such as trustworthiness, attractiveness and realism. The database includes both young and older versions. Moreover, the study aimed to verify the process of creating avatars with an accurate resemblance to the original imported photo and getting an older version of the avatar by using Character Creator 3.

4.2. Materials and method

4.2.1. Stimuli

Bodies: 27 digital bodies have been created in Character Creator 3. Avatars were created starting from two baseline avatar (male and female) **(Fig. 4.1),** provided by the software package.

Fig. 4.1 a) MY4 male avatar baseline b) FY4 female avatar baseline

Each avatar underwent the same transformation algorithm in order to create a body shape continuum (7 dimensions of weight) for each gender category (two conditions: female and male) and group age (two conditions: young and old).

BODIES ID	MALE WEIGHT CHANGES ALGORITHM	BODIES ID	FEMALE WEIGHT CHANGES ALGORITHM
MY1	MY4 + BODY THIN 100	FY1	FY4 + BODY THIN 100
MY2	MY4 + BODY THIN 50	FY2	FY4 + BODY THIN 50
MY3	MY4 + BODY TONE 100	FY3	FY4 + BODY TONE 100
MY4	50 CC3+ NEUTRAL MALE/ABS WIDTH 100	FY4	50 CC3+ NEUTRAL FEMALE/ABS WIDTH 100 / BREAST SCALE 50
MY5	MY4 + BODY BUILDER 50	FY5	FY4 + VOLUPTUOSUS 50
MY6	MY4 + BODY FAT 25	FY6	FY4 + BODY FAT 25
MY7	MY4 + BODY FAT 50	FY7	FY4 + BODY FAT 50

Tab 4.1. Algorithms of bodies shape modification- the values indicate the parameters used in Character Creator 3 in order to create different body shapes. MY4 (male, young) and FY4 (female, young) are the baseline bodies, created from the Character Creator's default body. Three thin versions were created from the baseline(MY1, MY2, MY3 for the male and FY1, FY2, FY3 for the female). Three bigger versions were also created from the baseline (MY5, MY6, MY7 for the male and FY5, FY6 and FY7 for the female).

Moreover, the age algorithm was applied to each body (see Fig. 4.2) with the following criteria:

- Skin: increasing wrinkles and spots
- Muscles: reducing volume and tonicity
- Hand: increasing visibility of bone structure
- Posture: accentuating curvature of the back

Fig. 4.2 *a) MO4 male aged avatar b) FO4 female aged avatar- Examples of older bodies. The age algorithm was applied to each young body shape.*

The avatar has been created both in Character Creator extension and in .fbx in order to be incorporated in Unity software for motricity testing. Each avatar underwent a motricity and usability testing in virtual reality scenario. It consists in fast check of the coordination of movements and its suitability to synchronization with virtual reality captures.

The videos for each avatar last seven seconds. In the video, each avatar spin of 360° on its cranium-caudal axis. The heads have been removed in order to let participant focus on body characteristics and not identity.

Faces

We selected from the Chicago Face Dababase (i.e., a validated database of extended faces of different races and emotion expressions, by Ma et al., 2015) 27 high resolutions photo of different identities (11 males) according to the following criteria:

- Age range: 20- 30 years old
- Race: Caucasian
- Emotion expressions: neutral
- Suitability for social studies (validated on a 5-point Licker scale by psychology researchers): greater or equal to four.

Each photo underwent a digital transformation with Headshot Plug-In of Character Creator. Headshot, the AI-powered Character Creator plugin generates 3D real time digital humans from one photo. This plug-in integrates Artificial intelligence modes: pro-mode and auto-mode. The first one is designed for high resolution texture processing and facial morph definition. Auto-mode makes lower definition avatar but allows generating 3d hair starting from the original photo. Pro Mode includes Headshot sculpting morphs, Image Mapping and Texture Reprojection tools.

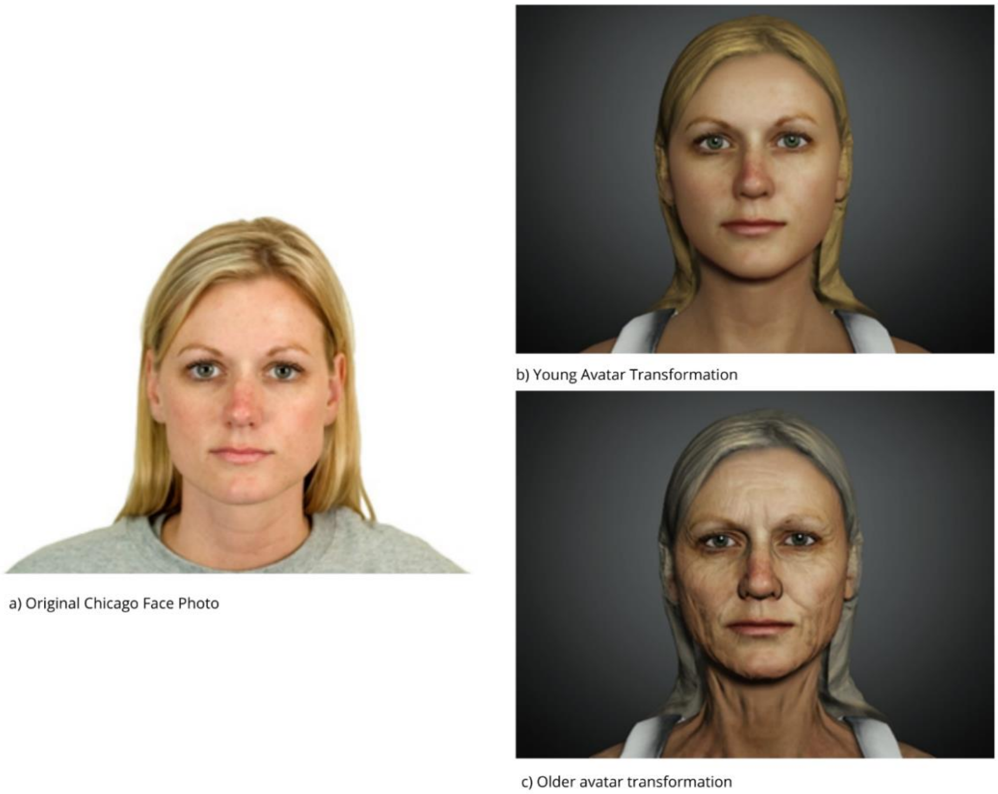

Figure 4.3. Example of avatar creation. On the left (a) one original selected photo of the Chicago Face Database according to selection criteria; on the right, the same age avatar creation (b) and older version (c).

Each Chicago face selected was digitalized via two modes: first via auto mode in order to create the digital hair; secondly via pro mode to create a higher resolution version of the avatar in order to increase realism. We applied a clean soft mask procedure to each avatar. The whole process takes 10 minutes for each identity.

Starting from the same age avatar, we applied some transformation in order to create the older version of the avatar:

- Very old face with eye shadow mask
- Age morph face: 30% intensity
- Hair textures: brightness +50% contrast -30%

Each avatar was saved in two file extensions (Character Creator and .fbx). We used as baseline the bodies of four categories (young male, young female, old male, old female). At the end we had 54 (27 young, 11 males) new images of both young and older avatar.

4.2.2. Procedure

1) **Subjective rankings of the bodies:** 61 participants (17 males) of two different age range (young adults, mean age 27.2 ± 4.10, and young old, mean age 64.9 ± 7.15) evaluated bodies videos through Qualtrics Online software. We measured perceived age ("What is the age of the body presented in the video?) on a visual analogue scale from 0 to 100. Moreover, on a 5-point Likert scale we tested some measures: masculinity, realism and ownership ("How likely is it to choose the following body to represent you in a virtual environment?"). We asked participants their weight and height in order to calculate BMI and evaluate the possible impact of their body shape on subjective rankings, especially in bodies' choice (Ownership).
2) **Subjective rankings of faces:** 42 participants (15 males) of two different age range (young adults, mean age 29.4 ± 5.20, and young old, 67.0 ± 9.32) evaluated bodies' videos through Qualtrics Online software. We measured perceived age ("What is the age of the avatar presented in the photo?) On a visual analogue scale from 0 to 100. Moreover, on a 5-point Likert scale we tested some psychological measures: masculinity, trustworthiness, attractiveness, unusuality ("Will this face stand out in a crowd?"), neutral expression (according to the original Chicago Face Database validation) and realism according to Katsiri and colleagues (2019), as items of Human likeness index. We aimed to evaluate the differences between young and

older participants in rating virtual avatar and identities, especially how they perceived young and old avatar of the same identity.

3) **Comparison with the original photo:** in order to verify the effectiveness of the procedure of creating an avatar similar to the original one, we asked the same 42 participants of experiment 2 to confront the original photo with both the young and older avatar. We asked to judge the similarity ("Are they the same person?"; "Are they the same person but of different ages?) on a 5-point Likert scale.

4.3. Results

Subjective ranking of the bodies

PERCEIVED AGE: All the analyses were conducted with Jamovi (version 1.6). We performed a Generalized Linear Mixed Model with Perceived age score as dependent variable and AVATAR AGE (young vs. old) and AVATAR SEX (female vs. male) as factors and subject as random intercept. We found a main effect of AVATAR AGE ($F(1,24.8) = 564.6311$, $p<0.001$). Moreover we found an interaction effect of AVATAR AGE and GROUP AGE ($F(1,1617.0)=11.5853$, $p<0.001$). (see Fig. 4.4, Tab 4.2)

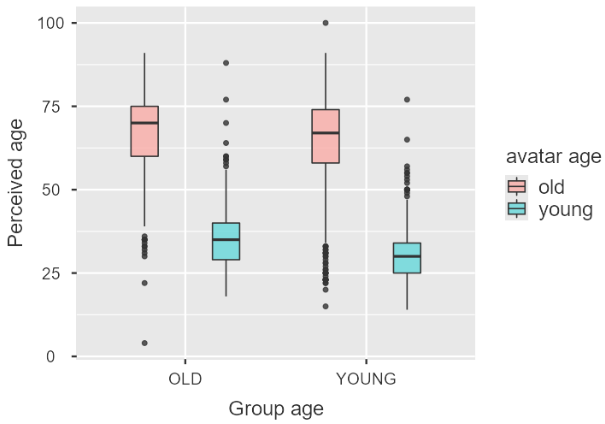

Figure 4.4 Effects plot: Means of perceived age by AVATAR AGE (old vs young) and GROUP AGE (young adults vs young old participants).

Tab 4.2 MEAN SCORES OF PERCEIVED AGE

					95% Confidence Interval	
avatar age	Group age	Mean	SE	df	Lower	Upper
old	OLD	66.3	1.304	75.0	63.7	68.9
young	OLD	35.8	1.304	75.0	33.2	38.4
old	YOUNG	64.1	0.911	75.0	62.3	65.9
young	YOUNG	30.1	0.911	75.0	28.3	31.9

Overall, Older bodies are perceived as elderly (65.2 years old) while young bodies are perceived as young adults (32.9 years old). However, young participants judged bodies as younger while old adults participants judged bodies as older.

MASCULINITY: We performed a Mixed Model with Masculinity as dependent variable and AVATAR AGE (young vs. old) and AVATAR SEX (female vs. male) as factors and subject as random intercept. We found a main effect of AVATAR SEX ($F(1,24) = 2592.81$, $p<0.001$). Moreover we found an interaction effect of AVATAR AGE and AVATAR SEX ($F(1,24)=40.44$, $p<0.001$). (see Fig. 4.5 and Tab. 4.3).

Figure 4.5. Effects plot: Mean values of Masculinity (1 Completely Feminine- 5 Completely Masculine) by AVATAR AGE (old vs young) and AVATAR SEX (female avatar vs male avatar).

Tab 4.3 MEAN SCORES OF MASCULINITY

					95% Confidence Interval	
avatar age	**avatar sex**	**Mean**	**SE**	**df**	**Lower**	**Upper**
old	female	1.81	0.0547	24.3	1.70	1.92
young	female	1.38	0.0547	24.3	1.26	1.49
old	male	4.24	0.0547	24.3	4.12	4.35
young	male	4.50	0.0547	24.3	4.39	4.61

Overall male bodies were perceived as more masculine (4.37) compared to the female bodies (1.59). However, old females were perceived as less feminine and older man as less masculine.

ATTRACTIVENESS: We performed a Mixed model with attractiveness as dependent variable and AVATAR AGE (young vs. old) and AVATAR SEX (female vs.

male) as factors and subject as random intercepts. We found a main effect of AVATAR AGE (F(1,24.2) = 67.9203, p<0.001). (see Fig. 4.6, Tab 4.4).

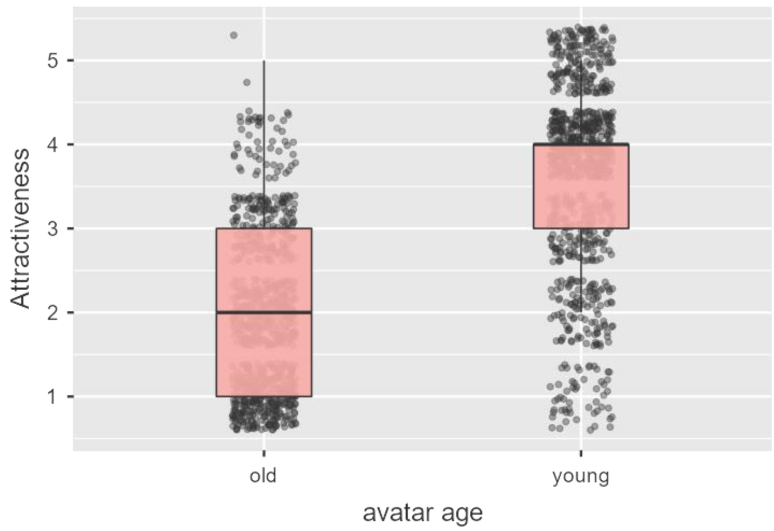

Figure 4.6. Effects plot: Mean values of attractiveness (higher score indicates preference for the avatar) by AVATAR AGE (old vs young).

Tab 4.4. MEAN SCORES OF ATTRACTIVENESS

				95% Confidence Interval	
avatar age	**Mean**	**SE**	**df**	**Lower**	**Upper**
old	1.97	0.156	35.1	1.66	2.29
young	3.62	0.156	35.1	3.30	3.93

Overall, younger bodies were perceived as more attractive to all participants.

REALISM: We performed a Generalized Linear Mixed Model with REALISM as dependent variable and AVATAR AGE (young vs. old) and AVATAR SEX (female vs. male) and GROUP AGE (young participants vs. old participants) as factors and subject as random intercept. We found a main effect of AVATAR AGE ($F(1,24) = 148.117$, $p<0.001$) and an interaction effect of AVATAR AGE and GROUP AGE ($F(1,1617)=9.343$, $p<0.01$). (see Fig. 4.7, Tab. 4.5).

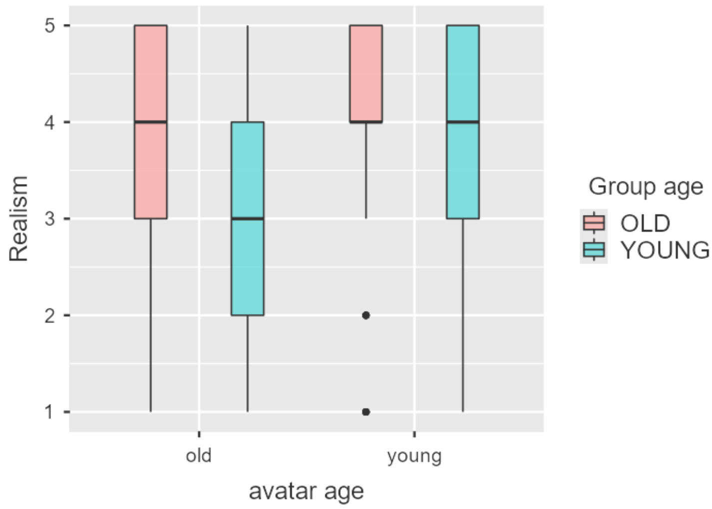

Figure 4.7. Effects plot: Mean values of realism by AVATAR AGE (old vs young) and GROUP AGE (young adults vs young old participants).

Tab 4.5 MEAN SCORES OF REALISM

					95% Confidence Interval	
avatar age	**Group age**	**Mean**	**SE**	**df**	**Lower**	**Upper**
old	OLD	3.64	0.216	64.1	3.20	4.07
young	OLD	4.16	0.216	64.1	3.73	4.59
old	YOUNG	2.97	0.152	66.0	2.66	3.27
young	YOUNG	3.74	0.152	66.0	3.43	4.04

Overall, older bodies were rated as less realistic compared to the younger one. Interestingly, young participants rated old bodies as even less realistic.

OWNERSHIP: We performed a Mixed Model with Ownership as dependent variable and AVATAR AGE (young vs. old) and AVATAR SEX (female vs. male) as factors, BMI (weight/height^2) as covariate, and subject and stimuli as random intercepts. We found a main effect of AVATAR AGE ($F(1,24)=79.39$ $p<0.01$) and AVATAR SEX ($F(1,24)=9.94$, $p<0.01$), but any effect of BMI index. (see Fig. 4.8 and Tab. 4.6). Overall participants rated with low ownership all the bodies. Moreover, older bodies show the lowest scores.

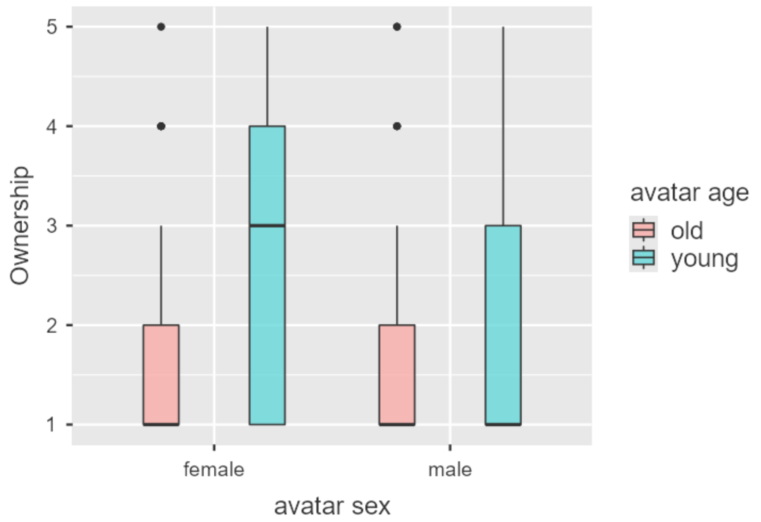

Figure 4.8. Effects plot: Mean values of ownership by AVATAR SEX (female vs male)) and AVATAR AGE (young vs old).

Tab 4.6. MEAN VALUES OF OWNERSHIP

					95% Confidence Interval	
avatar age	**avatar sex**	**Mean**	**SE**	**df**	**Lower**	**Upper**
old	female	1.55	0.135	46.6	1.27	1.82
young	female	2.81	0.135	46.6	2.54	3.09
old	male	1.47	0.135	46.6	1.20	1.74
young	male	2.19	0.135	46.6	1.92	2.46

Subjective ranking of the faces

We analysed the differences between the two groups for each dimension with a Mixed Model analysis performed on Jamovi Software (Version 1.6). We performed the analysis with each psychological measure as dependent variable and AVATAR AGE (young vs. old), AVATAR SEX (female vs. male) and GROUP (young participant vs. old participant) as factors, and subject and stimuli as random intercepts.

PERCEIVED AGE: We found a main effect of AVATAR AGE ($F(1,2218.0)=5403.184$, $p<0.0001$) and an interaction effect of GROUP and AVATAR AGE ($F(1,2218.0)=16.301$, $p<0.0001$). Old avatar were perceived as older than young avatar (according to the expected perceived age), however young participants perceived old avatar as older compared to old participants. (see Tab 4.7).

Tab 4.7 MEAN VALUES OF PERCEIVED AGE

					95% Confidence Interval	
avatar age	**Group age**	**Mean**	**SE**	**df**	**Lower**	**Upper**
old	OLD	66.3	1.70	44.8	62.8	69.7
young	OLD	31.2	1.69	43.3	27.8	34.6
old	YOUNG	71.0	1.64	46.8	67.7	74.3
young	YOUNG	31.8	1.61	42.8	28.6	35.1

MASCULINITY:

We found a main effect of AVATAR SEX (F(1,25.7)= 3601.58, p<0.0001).

Tab 4.8. MEAN VALUES OF MASCULINITY

				95% Confidence Interval	
avatar sex	**Mean**	**SE**	**df**	**Lower**	**Upper**
female	1.75	0.0315	39.6	1.69	1.81
male	4.25	0.0362	37.1	4.17	4.32

TRUSTWORTHINESS:

We found an interaction effect of avatar age and group age (F(1,2224.1)= 9.624, p<0.001). Older participants perceived younger avatar as more trustworthy. (see Tab. 4.9).

Tab 4.9 MEAN VALUES OF TRUSTWORTHINESS

					95% Confidence Interval	
avatar age	**Group age**	**Mean**	**SE**	**df**	**Lower**	**Upper**
old	OLD	3.08	0.0967	52.3	2.89	3.27
young	OLD	3.34	0.0957	50.1	3.15	3.53
old	YOUNG	3.20	0.0938	55.7	3.01	3.38
young	YOUNG	3.26	0.0913	49.9	3.07	3.44

ATTRACTIVENESS: We found a main effect of AVATAR AGE (F(1,2212.3)=32.912, p<0.0001) and an interaction effect of GROUP AGE and AVATAR AGE (F(1,2212.3)=12.115, p<0.001). Overall, older avatar were perceived as less attractive. However, older participants rated young avatar as more attractiveness compared to younger participants. (see Tab. 4.10).

Tab 4.10 MEAN VALUES OF ATTRACTIVENESS

					95% Confidence Interval	
avatar age	**Group age**	**Mean**	**SE**	**df**	**Lower**	**Upper**
old	OLD	2.81	0.152	51.2	2.51	3.12
young	OLD	3.15	0.151	50.1	2.84	3.45
old	YOUNG	2.89	0.146	53.5	2.60	3.18
young	YOUNG	2.97	0.144	50.5	2.68	3.26

Note. Means were estimated keeping constant other effects in the model.

UNUSUALITY: We found a main effect of AVATAR AGE (F(1,2224.2)=6.9899, p<0.01) and an interaction effect of GROUP AGE and AVATAR AGE (F(1,2224.2)=6.6212, p<0.01). Younger participants judged younger avatar as more unusual (stand out in a crowd) compared to the older one. (see Tab. 4.11).

Tab 4.11 MEAN VALUES OF UNUSUALITY

					95% Confidence Interval	
avatar age	**Group age**	**Mean**	**SE**	**df**	**Lower**	**Upper**
old	OLD	3.13	0.0717	52.0	2.99	3.28
young	OLD	3.13	0.0709	49.8	2.99	3.27

Tab 4.11 MEAN VALUES OF UNUSUALITY

					95% Confidence Interval	
avatar age	Group age	Mean	SE	df	Lower	Upper
old	YOUNG	3.08	0.0696	55.4	2.94	3.22
young	YOUNG	2.95	0.0676	49.6	2.82	3.09

NEUTRAL EXPRESSION: We found a main effect of AVATAR AGE (F(1,2230.3)=83.35446, p<0.0001) and an interaction effect of GROUP and AVATAR AGE (F(1,2230.3)=19.30651, p<0.0001). Young participants were perceived with a more positive expression compared to older avatar, even if in the range of neutrality. Specifically, even in this case, older participants judge young avatar expressions as more positive. (see Tab. 4.12).

Tab 4.12 MEAN VALUES OF NEUTRAL EXPRESSION

					95% Confidence Interval	
avatar age	Group age	Mean	SE	df	Lower	Upper
old	OLD	2.92	0.0786	65.4	2.76	3.07
young	OLD	3.30	0.0776	62.3	3.14	3.45
old	YOUNG	3.02	0.0769	70.3	2.87	3.17
young	YOUNG	3.15	0.0745	62.1	3.00	3.30

REALISM: We found a main effect of AVATAR AGE (F(1,2203.1)=68.813, p<0.0001) and an interaction effect of GROUP and AVATAR AGE (F(1,2203.1)=17.147, p<0.0001). Young avatars were perceived as more human-like, compared to older avatar. Moreover, young participants judged older participants as less realistic-like in bodies ranking results. (see Tab. 4.13).

Tab 4.13. MEAN VALUES OF REALISM

					95% Confidence Interval	
avatar age	**Group age**	**Mean**	**SE**	**df**	**Lower**	**Upper**
old	OLD	3.43	0.211	43.6	3.00	3.85
young	OLD	3.57	0.210	43.1	3.15	4.00
old	YOUNG	3.04	0.202	44.4	2.63	3.45
young	YOUNG	3.47	0.200	43.2	3.07	3.88

Comparison with the original photo

We asked participants to rate the similarity between the avatar created and the original photo. We analysed these judgements among participants to compare young and old avatar. In order to do so, we performed a Mixed model with Similarity scores as dependent variable, GROUP AGE (young population vs. old population), AVATAR AGE (YOUNG vs OLD) and AVATAR SEX (female vs. male) as factors, and subject and stimuli as random intercepts. We found a main effect of AVATAR AGE ($F(1,2029.0)=30.994$, $p<0.0001$) and an interaction effect of GROUP AGE and AVATAR AGE ($F(1,2029.0)=18.089$, $p<0.01$).

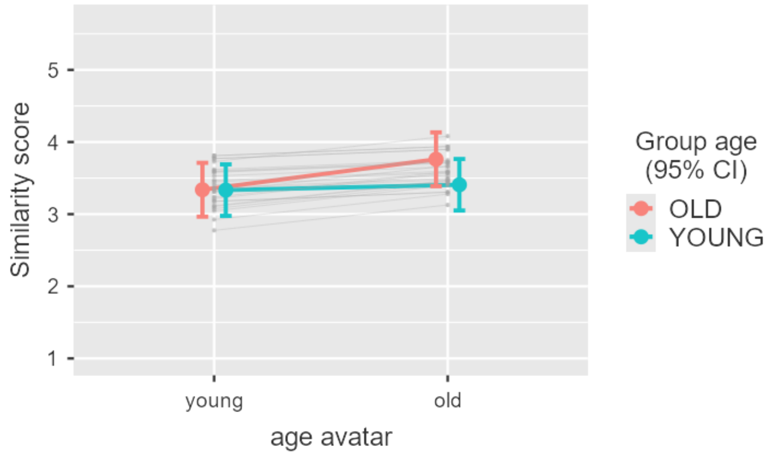

Figure 4.9. Effects plot: Mean of similarity scores by AVATAR AGE (old vs young) and GROUP AGE (young adults vs young old participants).

Overall, older avatar were perceived as more similar to the original photo. Moreover, older participants judged older avatar even more similar than young avatars.

Furthermore, all avatars, despite group age of the raters and avatar age, were perceived as medium similar with rating score over 3.0.

Tab 4.14 MEAN VALUES OF SIMILARITY

					95% Confidence Interval	
age avatar	**Group age**	**Mean**	**SE**	**df**	**Lower**	**Upper**
young	OLD	3.34	0.186	48.4	2.97	3.71
old	OLD	3.76	0.186	48.4	3.39	4.13
young	YOUNG	3.33	0.178	49.0	2.98	3.69
old	YOUNG	3.41	0.178	49.0	3.05	3.76

4.4. Conclusions

This research aimed to introduce a new approach and methodology in studying avatar characteristics, because of their importance in virtual reality paradigm.

In the last decades, virtual reality studies within psychological field were incredibly increased. Moreover, accessibility to complex virtual reality scenario as well as methodological and technological applications (i.e., high quality head-mounted display and CAVE) make it necessary to create a wide range of virtual reality stimuli and not only ad-hoc created ones by each experimenter. From this perspective, the influence of psychological aspects referred to the avatar on both embodiment dimensions (i.e., ownership and sense of presence) and their impact on attitudes and behaviours push us to consider avatar construction as one of the main fields of the methodological approach for future psychological studies in virtual reality.

In the first study, we created and validated a set of four categories bodies. These stimuli will be accessible for other studies and future research in the field of body image and stereotypes in ageing. Overall, older bodies were properly perceived as older and younger avatar as young, with no differences among gender or shape continuum. As expected, female and male avatars were correctly identified as female and male. Furthermore, our raters judged older avatars as having less gender prototypical characteristics and all participants judged older bodies as less attractive. These findings are in line with general literature about bodies changes associated to age and stereotype associate to older people.

Yet, Kite and Johnson (1988) found that older people are evaluated more negatively than younger people on some dimensions, such as physical appearance, but not on others, such as traits, points to the value of examining varied aspects of the stereotype. Sorell and Nowak (1981) noted that there is a congruence in the terms used to describe unattractive people and the elderly (Nowak, Karuza, and

Namikas, 1976). The limited research on gender and aging suggests that older women are evaluated more harshly than men, but this may be especially true when physical appearance is examined. Some stereotypes on ageing include characteristics such as being ill, tired, grouchy, unlikely to participate in activities, unhappy, undesirable for company, and physically unattractive (Crockett and Hummert, 1987; Lutsky, 1980; McTavish, 1971; Miele and Deaux, 1989).

Furthermore, we evaluated realism in order to investigate human likeness of our avatars. One issue in working in the digital environment and “fake human bodies” is to induce the feeling of eeriness, the so defined “uncanny valley”. According to Mori’s original definition (1970), as soon a robot or a digital alter ego acquires greater similarity to a human, it becomes emotionally appealing to the observer. However, when it becomes disconcertingly close to human appearance there is a drop in believability and comfort. The perfect match of a digital avatar will be with a medium human likeness (not too artificial not too human).

Avatars of bodies as well as faces are perceived as medium realistic. However, there is a huge effect of older bodies and faces, especially in younger participants raters. This may be explained by the combination of low quality definition of skin in older avatar creation, which may have increased eeriness in bodies and faces judgments, and the possible greater expertise of young participants who are more used to interacting with virtual environment and can be more accurate in noticing and qualifying differences among avatars. Further studies on human likeness will lead to better comprehension of the role of digital avatar expertise, as suggested by Katsiri (2018). Moreover, we aimed to assess the probability of body choice on shape continuum. In fact, we aimed to create a range of choice, representative of the main body shape characteristics. A possible application of this kind of stimuli is that it will allow participants to choose their virtual body or help researchers to investigate the impact of different body shapes on different psychological dimensions, such as body satisfaction, self-esteem but also modification in body characteristics in life span. We attempted to measure the probability of choosing a specific avatar with ownership dimension. However, results indicate lower scores for older avatar in all categories. The lower score toward older bodies may depends on some stereotypical dimensions of avoidance. We added at this analysis the BMI calculation. In a previous study, Thaler et al. (2018) investigated the influence of personal body size, indexed by BMI, on body size estimation using digital avatar in a female population. Their results show that the accuracy of participants body size estimation is predicted by personal BMI, whereas, participants with lower BMI underestimated their body size and participants with higher BMI overestimated their body size. Furthermore, in measuring the body choice there is a methodological limitation. The choice of a 3D digital body in a 2D image may influence the perception of feeling the body as suitable on ourselves. Other studies should investigate ownership (as well as other embodiment dimension like agency and self-location) of our digital bodies in a virtual reality immersive setting. A typical method used for studying the psychophysical effects of avatars and their appearance and properties on the users is based on the virtual mirror metaphor. In this metaphor, users approach a simulated mirror reflecting their virtual alter ego. To better-studying ownership, future research should use each avatar in virtual reality and investigate the impact on ownership.

The analyses of avatar identities suggest a coherent differentiation within the age of the avatar and the interaction between the age of the raters and the avatars group. These results suggest the suitability of our avatar identity for virtual reality but should also take in consideration the experimental design, the aim of the study and the age of the population. Some measures like attractiveness and trustworthiness are relevant in social cognition paradigms in virtual reality, such as interaction or social exclusion. While young participants have the same score toward all avatars, older participants may have some positive bias toward young avatars. This effect may have an influence in some paradigms and should be carefully taken into consideration but can also provide new insight about a possible utilisation of young avatar to induce some positive attitudes toward age process. As discuss in a previous study (Ch. 3) we know that is possible to modify attitudes toward a social group, by embodying a virtual avatar with the characteristics of the outgroup member. Less is known about the effect on self and ingroup evaluation; this kind of manipulation combined with high definition and well-structured digital agents could provide answer related to self-esteem, self-perception of ageing and self-view.

However the main limitation of the experimental results are the age and sex bias of the sample which have may affect some results such as masculinity and attractiveness judgement. A more extensive data collection should provide more reliable interpretations.

Finally, overall results and similarity scores suggest that Character Creator and the headshot plugin may be an interesting software to develop and study some avatar characteristics and investigate the impact of some psychological measures in virtual reality assessment. Moreover, other studies should investigate the perception of the physical resemblance of digital avatars with real participants' face. This methodology may be used to increase ownership as suggested by Waltermate (2018), but also may allow investigating the impact of different aspects of cognition on the self. For instance, this software allows creating, within the same identity, different age's manipulation but also different races and gender characteristics.

Part 2

"They reminded me that it was my fate to pursue only phantoms, creatures whose reality existed to a great extent in my imagination; for there are people - and this had been my case since youth - for whom all the things that have a fixed value, assessable by others, fortune, success, high positions, do not count; what they must have is phantoms. They sacrifice all the rest, devote all their efforts, make everything else subservient to the pursuit of some phantom. But this soon fades away; then they run after another only to return later on to the first."

— Marcel Proust, In Search of Lost Time

5. MEMORY IN HEALTHY ELDERLY: THE ROLE OF THE EPISODIC MEMORY

Despite neurocognitive changes happen during the whole life span, memory changes are commonly associated with age. Phrases such as "I can't remember", "I'm losing my mind" are stereotypically associated with elderly and with advancing age. In fact, memory is one of the cognitive functions that deteriorate most with age. However, behavioural and cognitive changes during age involving a natural lack of attention or generalized anxiety can often be confused with memory issues. Every young adult can describe at least one episode in which, after opening the fridge, they stared at the content without remembering the reason why they opened the fridge. Until middle age, this "forgetfulness" or "oversights" are attributed to other explanations rather than memory loss. However, memory difficulties themselves can in fact be increased by the focus that most people attribute to their age process. The self-perceived memory-changes contribute to the phenomenon, so-called dementia worry, an anxiety related response to the possibility of developing dementia (Molden et al., 2016). Although it is obvious that not all older adults develop dementia or memory problems, it is still true that something variates during life span and memory, as well as other cognitive processes, is subject to functional and structural modification. Why is it so important to study memory? Why do we remember? Why are we scared of “forgetfulness”?

To know the world around us, we can denominate, remembering facts, historical events, and make associations between concepts. We are able to remember, to manage information, to count, to speak and have a normal conversation and even if this skill belong to other cognitive domains, memory actually plays a substantial role in this ability. We can retain information for a while and use them to elaborate other information and complete daily life tasks. We remember because we can learn from the past and define who we are. In fact, our memories and real-life events contribute to define our identity and our self. We can recall information to remember the past, imagining the future by projecting our-self in different contexts and situations, reformulating different perspectives and anticipating future problems and increasing our problem solving and creativity skills. In this perspective, understanding how memory works and particularly what changes during life-span and how we can prevent possible decline occurring with age, could suggest different paths to promote well-being in both pathological and healthy ageing.

Despite cultural and research view and approach are changed, age is in ay case characterized by anatomical and functional modifications. One of the most famous and prototypical illnesses that combine memory and age is Alzheimer Dementia. It is characterised by memory difficulties that in the early stage are really difficult to distinguish from those of neurologically normal ageing. Since a lot of research focused on the neuropsychological aspects in pathological ageing, I would like to stress the fact that healthy memory progression should also be taken into account in order to promote well-being and to potentiate cognitive aspects. As I mentioned in this part of this work, to promote well-being and active ageing I referred to a multidimensional framework of successful ageing. In a review of the predictors of successful ageing, Depp and Jeste (2006) found that 13 out of 29 operational definitions of successful ageing consisted in indicators of cognitive functioning, and eight of those used clinical neuropsychological tools to measure them.

However, in the field of memory, what kind of changes can be defined as normal? From a functional point of view, functional neuroimaging helps us to individuate the crucial role of medial temporal lobe (MTL) and prefrontal cortex (PFC), theoretically related to the two major cognitive processes theories: resource and binding deficit hypothesis. These two theories together with brain functional compensation and the role of task demand could help in understanding what changes in normal ageing from a functional point of view. Working memory and episodic memory are the two types of memory most affected by the aging process. Working memory is related to the activity of prefrontal and parietal cortex (Wager & Smith, 2003). Episodic memory, related to the encoding and retrieval of personally-experienced events (Gabrieli, 1998; Tulving, 1983), is primarily dependent on the integrity of the medial temporal lobe (Milner, 1972; Squire, Schmolck, and Sark, 2001). Overall, the prefrontal cortex is the brain region that shows the greatest brain atrophy with age (Raz et al., 2005). The findings of studies on the role of PFC suggest that age-related decline in episodic and working memory depends on PFC, whereas pathological age modifications are more temporal-dependent (Buckner, 2004; Hedden and Gabrieli, 2004; West, 1996).

According to the **resource deficit hypothesis** (Craik, 1986) age related memory changes are the result of a generalized reduction in attentional activity and resources. Tasks that require greater self-initiated processing due to the lack of environmental support led to greater difficulties in older adults. In this framework, executive functions are fundamental to manage information and attentional resources during memory tasks. Moreover, even speed of processing (Salthouse,

1996) and inhibition deficits (Hasher, Zacks & May, 1999), frontal dependent factors, play a crucial role in attentional resources.

Another theoretical framework is the **binding** theory. This term refers to our capacity to bind elements into coherent representations: this process is particularly representative of episodic memory whereas a personal event is combined together with different sensory inputs, thoughts and emotions, and spatiotemporal representations. Since in memory retrieval recollection is defined as the remembering of an item with contextual details, and familiarity with the feeling of knowing that an item occurred without the ability of connecting contextual details referred to the event, we assume that in the binding theoretical framework, recollection is more critical than familiarity in older adults. Moreover, age related decline is clearly impaired in free recall of words and passages, memory for contextual details, working and prospective memory (Craik et al., 1995). Indeed, studies on PFC and episodic memory retrieval found prefrontal differences between young adults and older adults in tasks with less environmental support (context and recall memory task compared to simple recognition). Moreover, consistent finding in incidental and intentional encoding age-related reduction in the left prefrontal cortex activity often coupled with an increase in right PFC activity. In line with the resource deficit hypothesis, PFC reductions are more pronounced for intentional conditions, which require more self-initiated processing, than for incidental encoding conditions. For example, Logan et al. (2002) reported that during self-initiated, intentional encoding instructions, older adults compared with young adults showed less activity in the left PFC but greater activity in the right PFC, resulting in a more bilateral activity pattern. Results were similar for intentional encoding of both verbal and nonverbal material. Further exploratory analyses revealed that this pattern was present in a group of “old-old" but not in a group of “young-old”, suggesting that contralateral recruitment is associated with more pronounced age-related cognitive decline.

In contrast to blocked design episodic memory encoding studies, event-related fMRI studies using subsequent memory paradigms have often found age-related equivalent or increased activity in left PFC activity (Dennis, Daselaar, and Cabeza, 2006; Duverne, Motamedinia, and Rugg, 2009; Gutchess et al., 2005; Morcom et al., 2003). For instance, Morcom et al. (2003) used event related fMRI to study memory for semantically encoded words. Interestingly, performance of older adults at short delays was equal to young adults at long delays. Moreover, the left inferior PFC was greater for recognized compare to forgotten words in both groups.

The initial empirical evidence came from two experiments in which the so-called HERA model (Hemispheric Encoding/Retrieval Asymmetry; Tulving et al., 1994; Nyberg et al., 1996) was tested in young and elderly subjects (Cabeza et al., 1997a; 1997b). The original HERA model was based on young participants and suggested a functional hemispheric asymmetry of the PFC: whereby the left PFC would be more crucial during the encoding stages in episodic long-term memory (eLTM), the right PFC would be important during retrieval from eLTM.

Age-related reduction in frontal activity is normally associated with an increase of the same area of the opposite hemisphere. This pattern of activation has been conceptualized in a well-known model called "hemispheric asymmetry reduction in older adults" (HAROLD, Cabeza 2002). The evidence of this pattern has been derived from qualitative explorations of the data rather than statistical assessment of functional lateralisation, as underlined by Berlingeri (2013). For example, Rossi et al. (2004) were able to demonstrate a HAROLD effect (a disruption of performance regardless of the side of the frontal lobe inhibition) only for the recall phase of their memory task. However, Manenti et al. (2011) were able to confirm that a HAROLD effect is a characteristic of high-performing elderly individuals but only for the encoding phase of their paired-associated memory task. Interestingly, the opposite result emerged from an fMRI study by Duverne et al. (2009). Here, the HAROLD pattern was seen for the encoding phase of a memory task, but only in the low-performing elderly, suggesting that the hemispheric asymmetry reduction occurring in healthy ageing may not necessarily be of a compensatory nature. These finding open up a debate: does bilateral recruitment of the PFC represent the manifestation of a specific supportive cognitive strategy necessary to successfully complete a given cognitive task, or does it instead represent exclusively the neurofunctional manifestation of a cognitive effort?

In contrast, the **CRUNCH model** (compensatory-related utilisation of neural circuits hypothesis, Reuter-Lorenz and Cappell, 2008) stems from the well-known evidence of a direct correlation between task demands and BOLD responses in healthy young individuals. A similar correlation may exist also in older adults with different slope. The CRUNCH model posits that additional activations, regardless of the hemispheric side, are seen in elderly individuals for comparatively easier versions of the same task. However, as the task demands increase, older adults would reach a sort of plateau corresponding to the highest possible level of activation. At this point, their performance would inevitably fall due to the impossibility of meeting the additional task demands. The CRUNCH model was recently tested in a study by Schneider-Garces et al. (2010) in which elderly and young participants were invited to perform a working memory task with different cognitive loads. The results confirmed that elderly participants reached a ‘‘behavioural asymptote’’ accompanied by an asymptotic fMRI pattern for lower cognitive loads than young individuals. It is clear that the CRUNCH model is more general than the HAROLD and that a pattern conforming to the HAROLD may still conform to the CRUNCH model. Besides this general model of memory pattern during life span, one research field specifically focused on personal events and self-construction. In fact, autobiographical memory is a complex system, which increase in content but changes in mechanism.

Generally, episodic memory is associated directly with autobiographical memory, the system related to personal events of oneself. However, considering autobiographical memory as only episodic is reductive: the memories allow to construct a feeling of identity and continuity (Conway, 1997; Conway and Rubin, 1993).

Autobiographical memory, memory for information about oneself (Brewer, 1986), is subject to the same cognitive changes that affect the other memory processes. The key aspect of autobiographical memory is the fact that it concerns the memory of the self. An operational distinction proposed within autobiographical memory indicates a semantic component referring to general information about one's past and an episodic component, with specific events connotated by spatio-temporal details (Tulving et al., 1988). More precisely, the episodic component allows the spatio-temporal retrieval and the possibility of re-experiencing the past not only in the accuracy of recollection but also in the feeling of vividness associated with the memory. However, erroneously, autobiographical memory is often associated with episodic memory, since the second one refers to the memory for specific events. In fact, we never store in our memory a single event but a collection of personal and not personal events. Some of them are characterized by specific emotions, feelings and connotations of space and time. Others are daily and repetitive and, even if they contribute to our autobiographical memory and to define who we are, we can restore it as specific or unique.

For example, the way to go to work could always be the same: we take the same train, in the same city, at the same point, at the same time (if we are not late). If we are asked to talk about our way to go to work, we are able to retrieve our path and give some information about our routine.

This memory is in fact a collection of different episodic memories (Robinson, 1992). Neisser (1984) suggested that this repetition contributes to “semanticize” episodic memory.

Moreover, autobiographical memory contributes to defining our identity. Conway and colleagues (Conway and Pleydell-Pearce, 2000; Conway et al., 2004) conceptualized a framework called the self-memory system consisting of two main components: the working self and the autobiographical knowledge base. The first system is based on frontal activity and allows retrieving personal information on a conscious level; the second has three hierarchical levels of knowledge: lifetime period, general events, and event specific knowledge. In lifetime periods, the basis of this structure, personal eras are interconnected with the general knowledge of other activities and goals. The gradient of the autobiographical system then moves to general events, where there are repeated events, single extended events or sets of associated events. According to the episodic component of autobiographical memory definition, it is essential to remember vividly and consciously as the "event was still happening". All these levels refer to the events relevant to the self and contribute to the construction of identity.

According to the Tulving definition, episodic memory and semantic memory are two functionally and neuroanatomical independent memory systems related to the level of awareness activated: semantic memory gives the access to the noetic consciousness while episodic memory to the autonoetic consciousness that retrieved to the person the awareness that an event is truly part of their own personal past (Tulving, 1985). Additionally, several studies underline the role of the frontal lobe in autobiographical retrieval. Therefore, autobiographical remembering is mediated by the central executive process (Cohen, 1998). Consisting evidence comes from brain damages in which patients are unable to recollect personal events (Sala et al., 1993) and in which self-awareness is compromised. However, the frontal lobe seems to be more related to the retrieval of personal event rather than encoding: in fact, patients with bilateral prefrontal damage could recall further details if they can access to some cues, compared to the temporal lobe amnesia, which impair both episodic and semantic aspect of autobiographical memory. Age decline appears in the retrieval of context and source for memory, thereby the environment in which an item has been acquired. Schacter (1984) proposed two types of source memory deficits: 1) source amnesia in which an item is correctly recalled but the source is attributed to an external context different from the experimental session; 2) source forgetting, which increases with age, in which the modalities of the source are confused (e.g., visual or auditory).

The study of age effects on autobiographical recall has been guided by Ribot's Law (1881), according to which older information is better preserved than more recent information (Moscovitch and Winocur, 1992). The semantic nature of remote memory may explain the preservation of remote memory compared to recent memory in aged individuals. However, results remain controversial concerning remote memory in ageing, as they depend mainly on the method of assessment used and the type of autobiographical knowledge considered. Most studies used the cue-word method (Crovitz and Schiffman, 1974), based on the Galton paradigm (1883), where the participant is asked to provide the first specific memory that comes to mind for each cue-word, and then to date each of his/her memories. Studies that used this method compared the distribution of memories across the life-span of individuals of different ages. Based on these findings, Rubin (1986) proposed the breaking down of the temporal distribution of memories into three distinct components: the retention function, the reminiscence bump, and the infantile amnesia. The retention function for the 20–30 most recent years indicated a monotonic decrease in memories with the length of the retention interval and a very clear recency effect. From about 40 years of age, reminiscence bump corresponds to the increase in the number of remote memories recovered corresponding to the encoding period from 10 to 30 years compared to the surrounding periods (Fitzgerald, 1996a; Rubin, Rahhal, and Poon, 1998; Rubin and Schulkind, 1997a; 1997b; Rubin et al., 1986). Infantile amnesia concerns the smaller number of memories encoded before the age of 6, with practically a total absence of memories before the age of 3 (Perner and Rufman, 1995; Wetzler and Sweeney, 1986; Wheeler et al., 1997). Demonstration of a recency effect in individuals, whatever their age, has suggested that Ribot's Law is not borne out in normal ageing. Despite the evident fruitfulness of these studies, the methodological biases inherent in this technique are important and may affect the results (Dritschel, Williams, Baddeley, and Nimmo-Smith, 1992; Rabbitt and Winthorpe, 1988; but see Rubin and Schulkind, 1997a). The methodological biases mainly concern the somewhat artificial demands of the task, such as producing a personal memory to a particular cue word not always relevant to personal life, and the fact that often the person is not constrained to produce memories from a specific time- period (Piolino et al., 2014). Furthermore, different studies focused on semantic or episodic aspects within autobiographical memory, with different definition.

Otherwise, encouragement to be specific and scoring of memories are variable from one study to another and depend on that which we mean by episodic memory. Some studies, based on cross-sectional data, mainly concern the semantic aspects of auto-biographical memory. They examined the recall or recognition of a particular type of personal semantic knowledge (Bahrick, 1979: names of streets near the school; Bahrick, Bahrick, and Wittlinger, 1975: names and photographs of classmates) encoded at the same age by all the participants (for example the period of schooling) according to the retention interval. These studies show how it is very fast to forget at the beginning, then gradually slower; moreover, they highlight how recognition significantly improves performance (Kausler, 1994). These findings would suggest that autobiographical information is more difficult to recall with the passage of time, but that there exists, after a certain period of consolidation (4–6 years), a permanent store of autobiographical semantic information. Bahrick (1984) used the term permastore to designate the memory contents stored after a retention period of 6–25 years or more, concerning semantic information that is personal to varying degrees. However, although this procedure allows for better control of the encoded information, these studies have the disadvantage of not distinguishing between the length of the retention interval and the age of the person: performances according to the length of the retention period were obtained with individuals of increasing ages. The method of the semi-structured auto- biographical questionnaire (Borrini et al., 1989; Kopelman, Wilson, and Baddeley, 1989) was developed to answer the demands of neuropsychological assessment, while avoiding principal biases of the cue-word method, providing an evaluation of personal remote memory that can be compared to more traditional remote memory tasks which assess knowledge of public events and celebrities. The Kopelman et al. (1989) questionnaire (Autobiographical Memory Interview: AMI) is divided into a schedule involving the recall of personal semantic information (e.g., names of teachers, date and place of one's wedding, names of doctors) and another one involving the recall of autobiographical incidents (e.g., at primary school, one's own wedding or that of someone else, a holiday or journey last year), which are considered as episodic, from three distinct age periods: infancy to adolescence, young adulthood (18–30 years), recent past (last year). The autobiographical events questionnaire of Borrini et al. (1989) is fairly similar to that of Kopelman et al. (1989) with regard to the number of age periods examined (0–15, 15–40, 40 up to 2 years before completing the questionnaire) and the scoring of memories, which takes into account the richness of the description and the specificity of the recollection in time and place. However, unlike the AMI, this questionnaire does not concern especially specific events. Otherwise, each of the two questionnaires require to verifying the information produced, the one by talking to next of kin, checking medical records, and noting inconsistency in the subject's responses, the other by making a retest. Unlike Kopelman et al. (1989), Borrini et al. (1989) consider that their event-recall test results in the recall of repeated or rethought memories which have progressively become stereotyped and have, with time, acquired an organised structure of a personal semantic nature. This questionnaire was standardised using a population of 157 neurologically normal individuals aged over 55, according to age, sex, and educational level, to obtain normative data for the assessment of retrograde amnesia in amnesic patients. This study has shown a significant negative age effect on autobiographical memory for the three periods examined and has demonstrated that education level is more important than age effect in determining the deterioration of auto-biographical recall. The questionnaire of Kopelman et al. (1989) was proposed to distinguish between the episodic and semantic components of autobiographical memory. However, certain methodological limitations persist. The temporal resolution is too imprecise to allow for a detailed study of memory of the distant past, especially in elderly individuals, as a large time period between young adulthood and recent status is not examined with AMI. In addition, the remote age period tested (childhood and teenage or young adulthood periods) does not correspond to the same time interval according to the age of the subjects. The episodic memory score fails to discriminate between different levels of event recall (specific and general).

Levine et al. (2002) proposed an autobiographical Interview able to differentiate between internal and external details. The internal details referred to the "what" and details of an event, while external referred to a personal re-interpretation or related events to the main events.

Two issues arise from this premise: how do we evaluate autobiographical memory? Is it possible to dissociate the episodic component from semantic aspects, since episodic seems to be more compromised in older adults?

In the next chapter, I will discuss two different studies, that starting from episodic memory studies and ageing, aim to promote a new standardized protocol of cognitive stimulation for healthy older adults and a new task to quantify learning of episodic mechanisms.

6. STUDY 3 TIME: EPISODIC MEMORY COGNITIVE TRAINING FOR HEALTHY ELDERLY

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Abstract Healthy aging involves specific changes in episodic memory, with a relative saving of semantic and procedural components. Numerous studies have shown that intensive training focused on episodic memory has both specific effects and a cascading effect on other cognitive functions (such as executive functions and creativity). In particular, the effectiveness of these studies underlines the importance of shifting the focus of coding to the spatial-temporal and perceptive details that characterize an autobiographical event. From these studies, we have therefore developed a new cognitive stimulation protocol. The Intensive Episodic Memory Training (TIME), developed according to the principles of self-referentiality and temporality, includes oral and written exercises carried out in a group, which include both past episodic components and future imaginative. Participants are required to constantly move their selves along the timeline in order to stimulate episodic and prospective memory, future episodic thinking, divergent thinking, and problem solving. In this study, the experimental training was compared with a cognitive stimulation training already validated but not specific to memory. The study was attended by 31 participants cognitively healthy randomly assigned to the two stimulation groups. Each participant was evaluated before and after the 5 weeks of stimulation and after a further five weeks for follow-up evaluations. The evaluation was carried out through a complete battery of neuropsychological tests and well-being self report. The results indicate the effectiveness of the trainings, in particular, on the components of long-term memory and on positive relationship.

Keywords. Ageing, Cognitive training, memory

6.1. INTRODUCTION

Not all the young old (65-75 years old) underwent cognitive decline or reach dementia diagnosis. However, there are several age-related modification in episodic memory, attention and executive functions (Meijer et al., 2009; Tucker-Drob et al., 2009). This modification can affect quality of life and daily activities (Royall et al., 2000). In the last decades, particular attention has been addressed in creating interventions for healthy elderly in order to prevent cognitive impairment and increase quality of life. These strategies operate at different level: cognitive level with an increase of brain training stimulation, social, in order to improve positive relationship, and physical activity (Coley et al., 2008; Mangialasche et al., 2012). Cognitive training are obviously oriented to cognitive domain and in improving cognitive performance. Normally the cognitive training are programmes who aim to improve performance in at least one cognitive domain (Martin et al., 2011). Although their efficacy is demonstrate by a large literature, some limits concern the lack of ecological validity and the capability of transfer competence to everyday life functioning (Papp et al., 2009).

Recently has been proposed that cognitive training should be used as a preventing approach for reduce or prevent cognitive decline (Naismith et al., 2009; Mowszowski et al., 2010). Numerous trials have demonstrated the cognitive training efficacy that last even at follow up and affect cognitive and emotional measures (Zelinski, 2009). The positive effect of this training are not only directed to participants; also, carers and family member report a subjective sense of improvement to cognitive functioning (Walton et al. 2014).

Moreover, the subjective “feeling of improvement” have been empirically demonstrated, for example in knowledge and use of memory strategies (Kinsella et al., 2009; Naismith et al., 2013), perceptions of cognitive abilities (Smith et al., 2009) and well-being (Belleville et al., 2006). Besides the cognitive functions, physical activities and active social participation are important in healthy ageing and well-being in later life. For instance, active social participation is an important indicator of quality of life and prevent from depression (Díaz-López, et al., 2013; Pinazo & Sánchez, 2005). According to Ryff (1995) definition of well being, certain aspects of well being such as environmental mastery and autonomy increased with age, especially grom young adult to adulthood. Other aspects such as personal growth and purpose in life decrease in older age. Positive relationship with others and self-acceptance do not differ across ages. However maintaining a satisfying social life and prevent isolation is a good strategies to prevent dementia in later life.

According to constructive episodic simulation hypothesis (Schacter & Addis, 2007) having a flexible and constructive episodic memory play a key role not only in episodic memory details recollection but also in imagining or simulating future scenario based on previous experiences. Specifically, episodic simulation can be beneficial in different domain such as planning, prospective memory, decision making, problem solving and emotion regulation (Schacter, 2012). A decrease of specificity and richness of details in autobiographical memory (normally measured with Autobiographical Interview of Levine in terms of reported internal details) is associated with the process of healthy ageing (Addis, Wong and Schacter, 2008). A similar pattern is not limited to the episodic component of the autobiographical memory but also in episodic future thinking, the ability of imagine future events.

This relationship suggested a common influence of episodic memory on mental time line, specifically in the process of remembering (the past) and imagining (the future). Moreover, these findings are supported by fMRI studies in which episodic memory and episodic future thinking task show an overlap of activated brain region (Addis et al. 2007). The beneficial of episodic simulation are not specific for episodic memory. Madore and Schacter (2014) showed how the implementation of the level of details improves problem solving and creativity performance in young and older adults. The episodic specificity induction is a specific task in which participants are guided to focus in details retrieval of short film. Interestingly, the impact of episodic specificity induction is not limited to temporal and frontal cognitive domain (i.e. episodic memory, creativity, problem solving, prospective memory) but also in emotional process. For instance, Jing and colleagues (Jing et al., 2016) found preliminary evidence that specificity induction is relate to an increase of positive affect and decrease of negative one.

Based on episodic specificity induction and Schacter research we developed a cognitive training for healthy older adults who aim to increase details recollection and potentiate episodic recollection, future thinking and problem solving skills. Aim of the current research is to measure the efficacy of this cognitive training (TIME, Episodic memory intensive training) in a healthy population and compared the efficacy with a similar group of age who underwent a validated cognitive program (CAT protocol, Gollin et al. 2012).

6.2. Material and Method

6.2.1. Sample

31 participants were recruited for a cognitive intervention. Participants were recruited through advertisements in local newspapers and flyers, within a project led by the Associazione Alzheimer Monza e Brianza, in partnership with the Department of Psychology of the University of Milano-Bicocca.

They were all Italian speakers with no history of psychiatric or neuropsychological disorders with at least 65 years. After a general explanation of the aim of the research, participants who give their informal consent were randomly split into two training groups. 16 participants (3 males, mean age 72.8 ±, Cognitive Reserve Index CRI-Q= 118 ± 16.9) were assigned to the experimental group with the TIME protocol. 15 participants (4 males, mean age 71,2 ± 5,46, CRI-Q= 115 ± 16,4) were assigned to the control group with the CAT (Palestra per la mente) protocol.

All the participants gave their written informed consent to participate in the study. The project was approved by the Ethics Committee of the University of Milano-Bicocca and conducted in accordance with the 2013 Declaration of Helsinki.

6.2.2. Experimental design

The cognitive program last 10 sessions with a frequency of two pro week. Each session lasted one hour. We administered some cognitive and wellbeing assessment one week before starting the cognitive program (T0), one week after the end of the cognitive sessions (T1). Participants were then finally tested in a follow up session (T2) after five weeks by the end of the cognitive programs. The cognitive assessment was administered by two different Neuropsychologists (regularly enrolled in the Regional Register).

The project lasts one year. It was split into two phases: in the first recruitment (three weeks) 15 participants with no neurological disorder was assigned randomly to the two group training. They underwent cognitive assessment before, after the training and after 5 weeks. After 3 months by the end of the first recruitment, we started a new program in which we recruited other 16 participants that follow the same procedure.

6.2.3. Cognitive Training

Experimental training: TIME

Time protocol was developed by episodic specificity induction studies. The program is divided into 10 sessions of 1 hours each and organized in small group of participants (8 each time). With a combination of narrative and writing task, participants were trained to focus on increasing detail skill during retrieval of autobiographical memories, episodic future thinking, contrafactual thinking, problem solving and prospective memories task. The protocol was developed according to the principles of self-referentiality (every task was based on previous experience of the participant) and temporality (projection in the past or in the future). Each session had a main life span theme (i.e. childhood, friendship). The structure of exercise and the task was the same among the sessions. Participants were asked to write with as much details as possible an event real or plausible, according to the exercise (the first memory, Me in ten years, what would happen if, etc.).

Control training: PALESTRA PER LA MENTE

CAT protocol (Gollin et al. 2012) was developed starting from previous experiences (Reality Orientation Therapy, Reminiscence and Re-motivation) performed within the frame of errorless learning principles, with the reinforcement of social health education. The original treatment is divided into 18 sessions of 4 hours each and it is organized in small group as well. We adapted the sessions to compare the term with the experimental protocol. CAT protocol is effective to improve cognition and functional status in patient with mild to moderate Alzheimer's disease (Gollin et al. 2013).

6.2.4. Neuropsychological assessment

We administered several cognitive test in order to assess the efficacy of the training on different domains. The MOCA (Nasreddine et al., 2005; Traduzione a cura di Pirani, Tulipani, Neri, versione del 2006), was administered as a screening instrument for cognitive impairment. Attention skills were evaluated through Stroop Test and Trail Making Test (Siciliano et al., 2019, Caffarra et al., 2002). Memory was assessed with the Rey auditory verbal learning test (immediate and delayed recall trials, respectively RAVLT-I and RAVLT-D; Carlesimo et al., 1996), Digit Span Forward (DSF; Monaco et al., 2013) and Digit Span Backward (DSB; Monaco et al., 2013). Tower of London (Shallice, 1982; Allamanno et al., 1987) was used to assess planning and problem-solving. The language was evaluated using the Semantic Fluency Test, the Phonemic fluency tests (Carlesimo et al., 1996). All participants were also administered the Cognitive Reserve Index questionnaire (CRIq; Nucci et al., 2012), which conveys in a single measure the three main sources of CR, i.e., education, working activity and leisure time activities, each of them also recorded as a sub score. The neuropsychological assessment lasted approximately 90 min.

6.2.5. Well-being Self Report

Since we are interested on the impact on both cognitive performance and functional skills, specially the well-being dimensions, besides the cognitive assessment we administered a self-reported scale of well-being.

Psychological well-being (PWB) studies has rapidly increased in the last decades (Ruini et al. 2003). The theoretical Framework of the well-being approach is based on World Health Organization's conception of health (1946), that not only aim at preventing disease, but at reaching a state of complete physical, mental and social well-being.

Ryff (1989) developed a multidimensional model of psychological well being, based on an extensive review of the scientific literature, and the integration of clinical, human positive functioning and developmental life span theories. The model proposed by Ryff have six dimension: positive attitude toward the self and one's past life (Self-Acceptance); a close, trusting and open relationships with others (Positive Relations with Others); self-regulation and independence (Autonomy); the competence to manage the environment and external activities (Environmental Mastery); a belief in the meaning to one's present and past life (Purpose in Life); a sense of improvement or expansion over time (Personal Growth) (Ryff, 1995). Furthermore, The Ryff's PWB Scales are one of the most widely applied measures of Psychological well being in clinical and general samples, different for gender, age, marital status, level of education, health, and other aspects of well-being (Clarke et al. 2001; Keyes et al. 2002; Ryff 1989; Ryff and Keyes 1995). We used for our assessment the 18 item version. (Springer and Hauser 2006).

6.3. Results

6.3.1. Cognitive assessment

We calculated all the z scores for each neuropsychological test with the mean and deviation standard of the targeted population of the standardized evaluation. Analyses were conducted with Jamovi Software (Version 1.6). First, we verified that at the baseline (T0), all participants of each group had homogeneous performance in each test. In order to this, we conducted a mixed model analysis with Zscores as dependent variable, Training group and Cognitive test as factors, Age and Education as covariates and participants as random intercept. We did not find pre-existing differences between the two groups (TIME and PM) before starting the training program, for AGE (p=0.9400) Education (p= 0.6859) and Test (p=0.9706). (see Fig. 6.1)

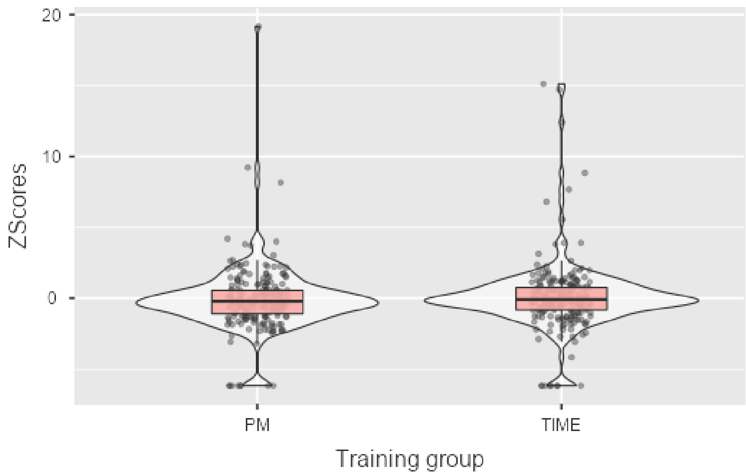

Figure 6.1 Mean differences at baseline evaluation (T0) at Neuropsychological assessment in two Training group

After that, we performed a global evaluation of differences in evaluation during time and between groups.

We performed a Mixed Model with Zscores as dependent variable, Time (T0, T1, T2), Training Group (Time vs. PM) and Test as factors, Age and Education as covariates and participants as random intercept. We found an interaction effect of Test and Time (F(32,1250.1)=5.155, p<0.0001, but any difference between two groups.

We then performed a sensitivity analysis for each Neuropsychological Test to evaluate the performance in Time between two groups. For each zscores test as dependent variable, we conducted a mixed model with Time (T0, T1, T2) and training group (Time vs. PM), Age and Education as covariates and participants as random slope. We reported only significant results.

Rey's 15-word list immediate

We found a main effect of Time (F(2,57,4)=51.49902), p<0.0001) but any difference between Training groups. Specifically participants in both cognitive stimulation groups show an increase of the performance between T0 and T1 and T0 and T2 (see Figure 6.2, Tab 6.1)

Tab 6.1. Fixed Effect Parameter Estimates Rey's 15 words list Immediate

				95% Confidence Interval				
Names	**Effect**	**Estimate**	**SE**	**Lower**	**Upper**	**df**	**t**	**p**
(Intercept)	(Intercept)	-0.8379	0.2902	-1.407	-0.2691	27.1	-2.8872	0.0075
Time1	T1 - T0	3.5839	0.4409	2.720	4.4480	57.1	8.1284	< .0001 **
Time2	T2 - T0	4.1433	0.4453	3.270	5.0161	57.5	9.3036	< .0001 **

Tab 6.1. Fixed Effect Parameter Estimates Rey's 15 words list Immediate

				95% Confidence Interval				
Names	**Effect**	**Estimate**	**SE**	**Lower**	**Upper**	**df**	**t**	**p**
Training group1	TIME - PM	0.0544	0.5857	-1.094	1.2024	27.0	0.0929	0.9267
Age	Age	-0.0525	0.0480	-0.147	0.0416	27.3	-1.0939	0.2836
Education	Education	-0.0115	0.0796	-0.167	0.1444	28.2	-0.1446	0.8860
Time1 ✻ Training group1	T1 - T0 ✻ TIME - PM	-0.7518	0.8818	-2.480	0.9765	57.1	-0.8525	0.3975
Time2 ✻ Training group1	T2 - T0 ✻ TIME - PM	-0.5865	0.8908	-2.332	1.1594	57.5	-0.6584	0.5129

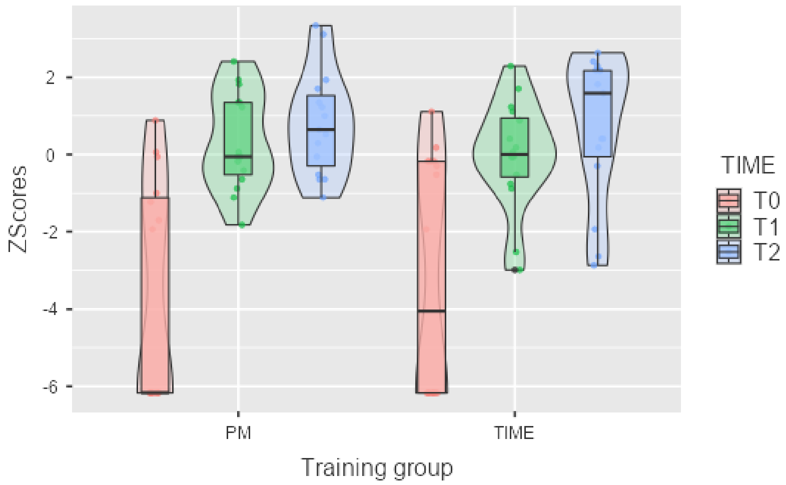

Figure 6.2 Mean differences at Rey's 15 List Word Immediate in TIME (T0,T1, T2) and Training groups (Time vs. PM)

Rey's 15-word list delayed

We found a main effect of Time (F(2,56,8)=15.604), p<0.0001) but any difference between Training groups. Specifically we can observe an improvement of the performance between T0 and T2. (see Fig. 6.3, Tab. 6.2).

Tab 6.2 Fixed Effect Parameter Estimates Rey's 15 words list delayed

				95% Confidence Interval				
Names	**Effect**	**Estimate**	**SE**	**Lower**	**Upper**	**df**	**t**	**p**
(Intercept)	(Intercept)	-0.2087	0.2451	-0.68913	0.27164	26.7	-0.8517	0.4020
Time1	T1 - T0	0.3791	0.1899	0.00698	0.75122	56.7	1.9967	0.0507
Time2	T2 - T0	1.0607	0.1921	0.68422	1.43713	56.9	5.5223	< .0001**
Training group1	TIME - PM	-0.0487	0.4950	-1.01882	0.92146	26.7	-0.0984	0.9224

Tab 6.2 Fixed Effect Parameter Estimates Rey's 15 words list delayed

				95% Confidence Interval				
Names	**Effect**	**Estimate**	**SE**	**Lower**	**Upper**	**df**	**t**	**p**
Age	Age	-0.0723	0.0404	-0.15146	0.00690	27.1	-1.7892	0.0848
Education	Education	0.0375	0.0658	-0.09142	0.16639	29.7	0.5700	0.5730
Time1 ✻ Training group1	T1 - T0 ✻ TIME - PM	-0.7041	0.3797	-1.44832	0.04016	56.7	-1.8542	0.0689
Time2 ✻ Training group1	T2 - T0 ✻ TIME - PM	-0.7262	0.3841	-1.47900	0.02660	56.8	-1.8907	0.0638

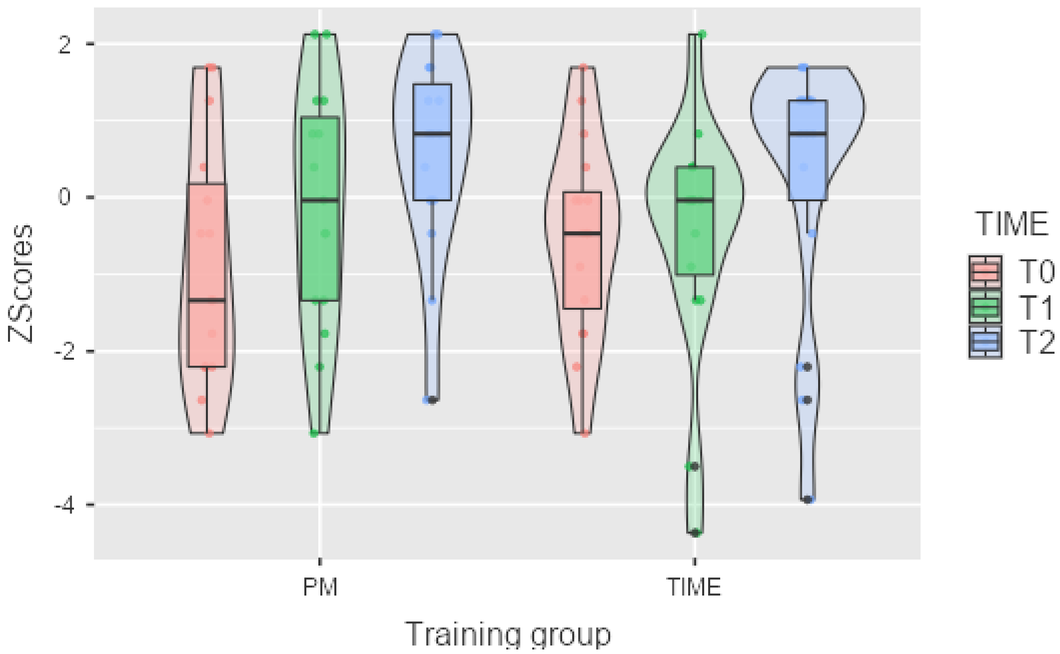

Figure 6.3 Mean differences at Rey's 15 List Word Delayed in TIME (T0, T1, T2) and Training groups (Time vs. PM)

Trail Making Test B-A

We found a main effect of Time (F(2,57,3)=4.467), p<0.0001) but any difference between Training groups. (See Fig. 6.4, Tab. 6.3). Participants in both group, improve their performance between T0 and T1, and between T0 and T2.

Tab6.3 Fixed Effect Parameter Estimates Trail Making Test B-A

				95% Confidence Interval				
Names	**Effect**	**Estimate**	**SE**	**Lower**	**Upper**	**df**	**t**	**p**
(Intercept)	(Intercept)	-0.05764	0.0836	-0.22150	0.1062	27.2	-0.689	0.4964
Time1	T1 - T0	-0.23543	0.1018	-0.43491	-0.0359	57.2	-2.313	0.0243**
Time2	T2 - T0	-0.28693	0.1029	-0.48854	-0.0853	57.4	-2.789	0.0072**
Training group1	TIME - PM	-0.04083	0.1688	-0.37164	0.2900	27.1	-0.242	0.8107
Age	Age	0.03698	0.0138	0.00991	0.0641	27.4	2.677	0.0124
Education	Education	0.00607	0.0228	-0.03863	0.0508	28.6	0.266	0.7921
Time1 ✻ Training group1	T1 - T0 ✻ TIME - PM	-0.12283	0.2036	-0.52179	0.2761	57.2	-0.603	0.5486

Tab6.3 Fixed Effect Parameter Estimates Trail Making Test B-A

				95% Confidence Interval				
Names	**Effect**	**Estimate**	**SE**	**Lower**	**Upper**	**df**	**t**	**p**
Time2 ✻ Training group1	T2 - T0 ✻ TIME - PM	0.04445	0.2057	-0.35879	0.4477	57.4	0.216	0.8297

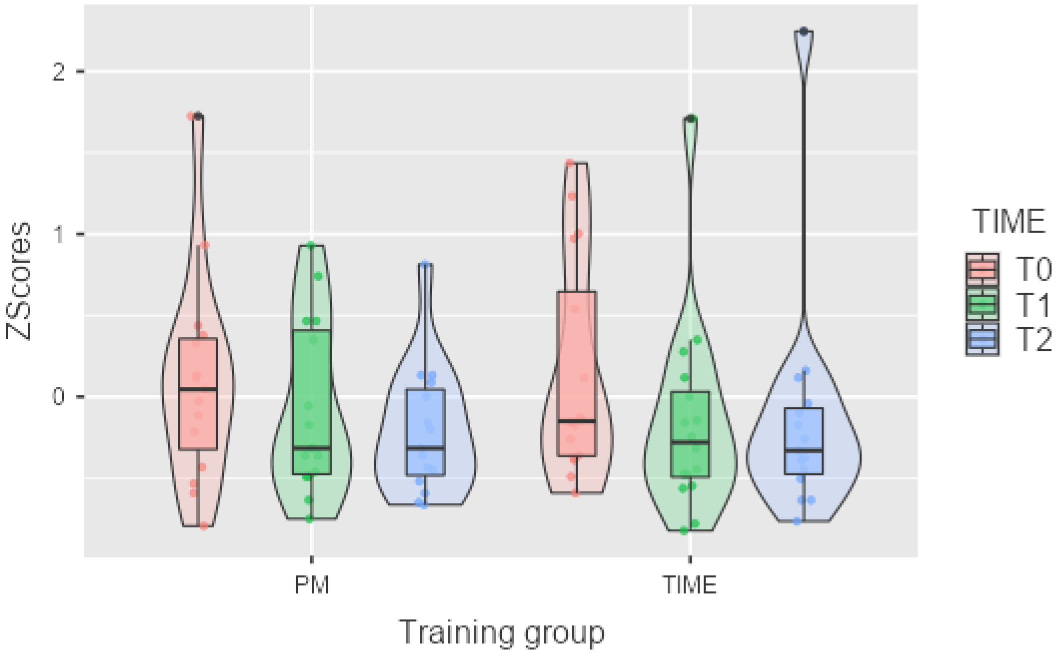

Figure 6.4 Mean differences at TMT B-A in TIME (T0, T1, T2) and Training groups (Time vs. PM)

Rey-Osterrieth figure Recall

We found a main effect of Time (F(2,57,0)=3.217), $p<0.05$) and a close to significant interaction between Time and Training Group. (see Fig. 6.5, Tab 6.4). We can observe an improvement of the performance only at short term, between T0 and T1. However Time protocol participants show an improvement also at T2.

Tab 6.4 Fixed Effect Parameter Estimates Rey-Osterrieth figure Recall

Names	Effect	Estimate	SE	95% Confidence Interval Lower	95% Confidence Interval Upper	df	t	p
(Intercept)	(Intercept)	-0.3937	0.1347	-0.6577	-0.1298	26.9	-2.9241	0.0069
Time1	T1 - T0	0.3808	0.1502	0.0864	0.6752	56.9	2.5354	0.0140**
Time2	T2 - T0	0.2003	0.1518	-0.0972	0.4979	57.1	1.3195	0.1923
Training group1	TIME - PM	-0.2116	0.2719	-0.7445	0.3212	26.8	-0.7784	0.4432
Age	Age	-4.36e−4	0.0222	-0.0440	0.0432	27.1	-0.0196	0.9845
Education	Education	0.0143	0.0366	-0.0576	0.0861	28.5	0.3893	0.6999
Time1 ✻ Training group1	T1 - T0 ✻ TIME - PM	-0.1268	0.3004	-0.7155	0.4620	56.9	-0.4220	0.6746
Time2 ✻ Training group1	T2 - T0 ✻ TIME - PM	-0.7076	0.3037	-1.3028	-0.1124	57.1	-2.3300	0.0234

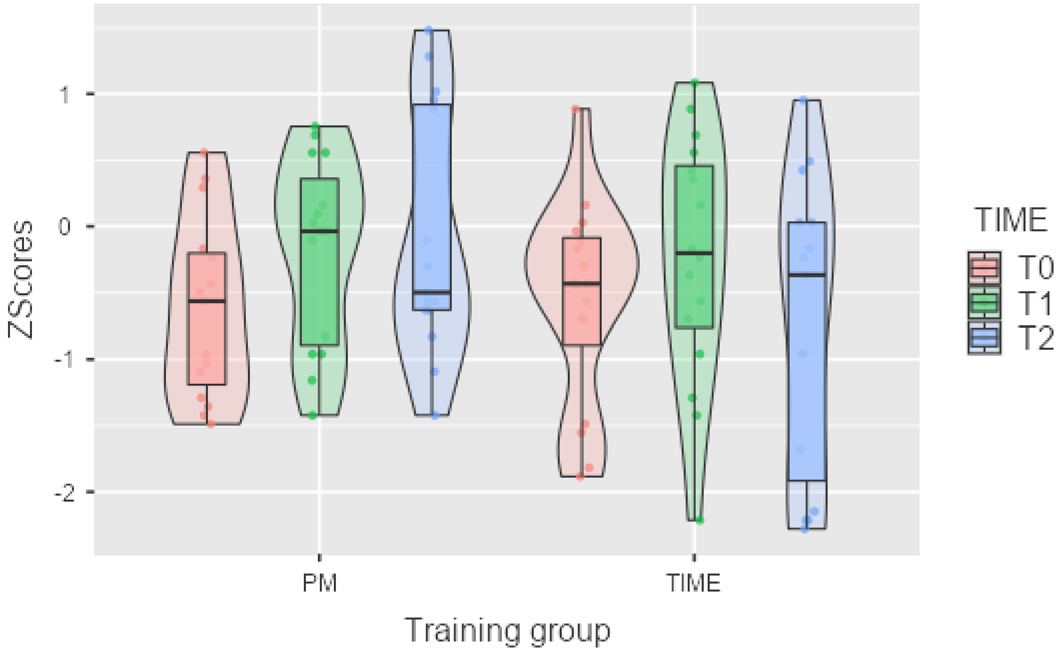

Figure 6.5 Mean differences at Rey-Osterrieth figure Recall in TIME (T0, T1, T2) and Training groups (Time vs. PM)

6.3.2. Well-Being assessment

We performed a Mixed Model with Well-being Subdimensions Scores as dependent variable, Time (T0, T1, T2), Training Group (Time vs. PM) as factors, Age as covariates and participants as random intercept. We found an interaction effect of Positive Relationship Subdimension ($F(2,31.1)=9.670$, $p<0.001$ between Training Group and Time. (see Fig. 6.6).

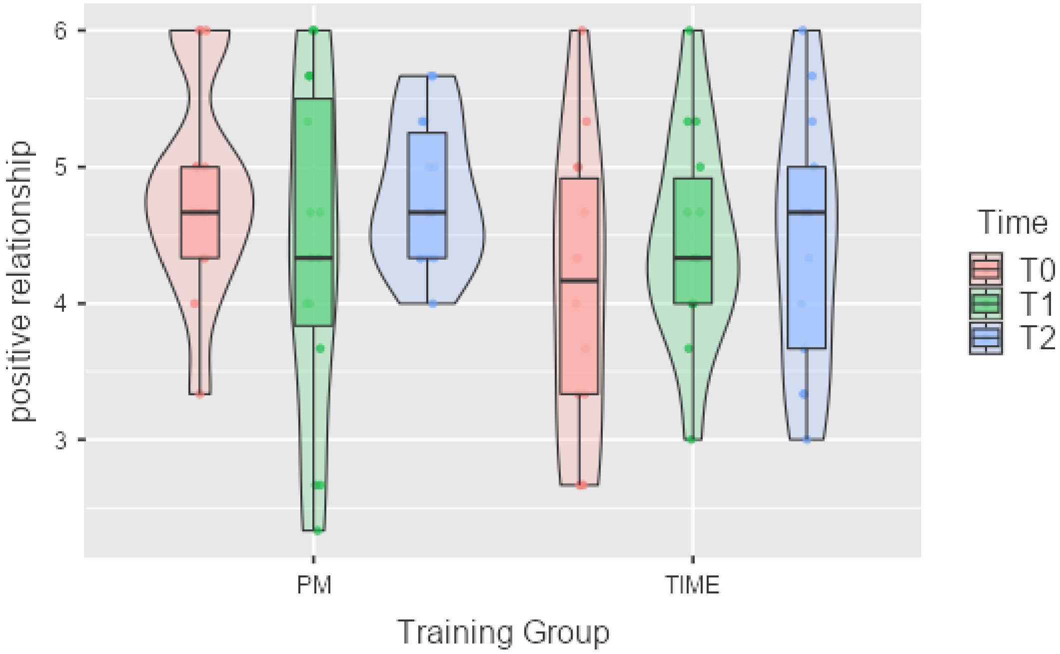

Figure 6.6Mean of Positive Relationship subscale score in TIME (T0, T1, T2) and Training Groups (Time vs. PM)

6.4. Conclusions

Personal episodic memory allows people to mentally travel through subjective time, from the present to the past, and to recall their previous experiences (Brewer, 1996; Baddeley, 2001; Gardiner, 2001, Tulving, 2001, 2002; in Piolino et al., 2009). However, according to Piolino (2006) the ability to consciously remember many specific events and to relive the context in which they occurred deteriorates with age (Piolino et al., 2006). This work aimed to create an innovative protocol for healthy young old with the objective of improve cognitive functions and wellbeing. The training were structured in order to be more ecological, related to personal life of participants and to involve social relation between participants at the training. Results, compared with an already protocol of cognitive program (CAT, Gollin et al., 2012), show promising direction toward cognitive improvement. Specifically our participants show overall an increase of long term memory abilities, spatial and verbal.

Moreover, based on well-being self-report, our participants show an increase of positive relationship among time. According to the original definition, the positive relationship subscale is defined as “person has warm, satisfying, trusting relationships with others; is concerned about the welfare of others; is capable of strong empathy, affection, and intimacy; understands give-and-take of human relationships”. Since positive relationship do not change during life span, but it can influence mood and depression in later life, we supposed that our cognitive training could be a valid method to promote well-being.

However, other studies are required to validate this protocol; specifically other interventions should be direct to a larger sample size of different age cohort. Moreover, to assess the efficacy in episodic memory task, in association with global neuropsychological assessment, other episodic memory task should be take into consideration. In future studies we will aim to combine this project and measure the effect on TEMPO, a task developed to assess the process of personal event learning in a mental time line. Overall, these findings are a first attempt to investigate the impact of this kind of cognitive program in healthy ageing.

7. STUDY 4 TEMPO: testing episodic memory learning in older adults

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Abstract. Episodic memory is one of the cognitive functions more affected in ageing. Recent studies on mental time travel suggest a correlation between spatial and temporal representation in long-term memory. Specifically, the distance effect reflects the ordinal comparison between two mental events and indicates that participants are slower and less accurate when temporal and spatial distances are close to their mental point of view, while they are faster and more accurate when distances are far away. This phenomenon is evident in consolidated temporal and spatial representations. Considering the lack of specific tasks to assess the temporal component of episodic events, we aimed at developing a new task to assess the ability of collocate events on the personal time line in young and older adults and comparing this measure with classical neuropsychological tests for memory assessment. Our results suggest the presence of a distance effect even for personal events learned in both age group and a specific relationship with spatial working memory abilities in young population.

Keywords. Episodic memory, distance effect, ageing

7.1. Introduction

Episodic memory is one of the cognitive functions more affected in ageing. Specifically, autobiographical context episodic memory defines the details and the spatiotemporal information associated to an event. Fewer details recollection of life events is associated with healthy ageing and greater impairment in episodic memory functioning (Pause et al., 2013). In fact, according to Piolino (2006), the ability of consciously remember many specific events and to relive the temporal and spatial context in which they occurred deteriorates with age. This modification in retrieval may be applied also to episodic future thinking, the "episodic component" of memory projected in the future. In a study by Addis (2008), they used an adapted version of the autobiographical interview (Levine et al., 2002) to disentangle internal and external episodes within autobiographical memories. Internal details can be compared to the episodic component and consist of specific information about the who, what, where, and when of a retrieval experience. External details are more semantic and involve facts or references to other events. In another study of Madore et al. (2013) older adults autobiographical interview reported significantly fewer internal details and more external details about both past events and imagined future events than young adults. Moreover, autobiographical memories are retrieved and narrated many times and, due to their constructive and dynamic nature, there may be changes in the content and stability of the memory over time (Schacter et al., 1998; Walker et al., 2003; Earles et al., 2008). One issue in autobiographical memory assessment is also to verify the veracity of the episodic memories among individuals and the greater emotional influence that may affect some memories. To overcome this problem some recent studies aimed to assess the episodic component of autobiographical memory with virtual reality paradigms (Abichou et al., 2017, 2021). In these studies, participants virtually navigated in a city and encounter some events. At the end of each navigation, they were asked to recollect the events with more details as possible. The advantages of this kind of studies are the possibility of studying episodic memory in an ecological context and to assess the veracity of the event and the details and counterbalance for emotional aspects.

Long-term memory events have a precise spatial-temporal location. Currently, the main long-term memory tests investigate the ability to memorize and recover non-personal material or without the temporal component (e.g., Rey's 15 words list). Similarly, autobiographical memory allows studying the recovery of personal events, in its voluntary and involuntary components, but there are no methods to study the process of coding personal information in time. Further studies should assess episodic memory and spatiotemporally learning process and provide a fast and easier task to assess this component in life span. Only recently, some studies have tried to better investigate these processes through paradigms based on mental time travel, that is the ability to recall past events and imagine future ones. According to Gauthier and Wassenhove (2016), spatio-temporal events are internally represented along a Mental Time Line (MTL) that maintains content related to their position in space and time. The distance effect reflects the ordinal comparison between two mental events and indicates that participants are slower and less accurate when temporal and spatial distances are close to their mental point of view, while they are faster and more accurate when distances are far away (Gauthier and Wassenhove, 2016).

In this study, participants were asked to judge the order of different historical events placed in time and space with respect to different perspectives: in particular, they had to judge whether a certain event had occurred before or after a target event, or east or west of a certain location. In all experiments, the effect of symbolic distance, reflected in the dimensions of time and space, was quantified using response times (RT) and error rate (ER). When the temporal and spatial distances were close together, the participants were slower and less precise (effect of absolute distance); the participants were faster and more precise when the spatial and temporal distances were further away from the adopted perspective (relative distance effect). These results suggest, therefore, that space-time events are represented internally along a continuum that maintains specific contents related to their location in space and time. We assumed that if the events were properly consolidated from a temporal view, the mental time navigation should have been faster.

Our work aimed to assess the learning of new similar personal events and measure their retrieval, specifically the ability of collocating the events in a temporal line. Our paradigm is based on Mental Time Travel, i.e., the ability to recall past events and imagine future ones (Tulving, 1985, 2002; Atance & O'Neill, 2001; Levine, 2004; Levine et al., 2004). Based on these assumptions, the aim of the present work was to study and evaluate episodic memory in healthy ageing by comparing these data with the young adult population. We recreated a task similar to Gauthier and Wassenhove (2016) with analogous personal events and the distance effect between the items has been tested. We aimed to replicate the distance effect for our events and calculated a random slope of the effect for each participants. Our hypothesis was that greater values of random slope were associated to the ability of remembering better events in a temporal way. Moreover, we compared our task with other neuropsychological tasks, in order to evaluate whether some long term memory test could predict this ability.

7.2. Method

7.2.1. Sample

Study 1: 24 young adult participants (12 males, mean age: 23.75 ± 2.308) took part in the experiment. They were all Italian speakers and had no history of psychiatric or neuropsychological disorders. All participants were students at the University of Milano-Bicocca.

Study 2: 17 young old participants (9 males, mean age: 69.16 ± 2.72) took part in the experiment. They were all Italian speakers and had no history of psychiatric or neuropsychological disorders, except for one participant with an early onset of Parkinson disease. Before starting the experiment, all participants underwent MOCA cognitive assessment.

According to the power analysis conducted, an a priori sample size should have been of 23 participants for each group. However, due to the Covid-19 pandemic, we tested less healthy older participants.

7.2.2. Stimuli

48 personal events balanced for character length were validated in a corollary experiment. 20 Italian participants (20-30 years old University students) were asked to rate events on a 7-point Likert scale for valence and vividness. The events with average scores (mean valence 5.47 ± 0.470; mean vividness of 5.11 ± 0.428) were selected as target stimuli, for a total of 24 neutral events. They were then randomly divided into four blocks (A, B, C, D). The events are the following:

- Eating a dessert
- Seeing a dear friend again
- Changing residence
- Having an appointment
- Travelling for several days
- Going to a concert
- Enrolling in a course
- Taking the plane

- Reading a newspaper
- Reading the news
- Buying a dress
- Going out for an intimate dinner
- Making friends
- Staying home on holiday
- Resting on the sand
- Read lots of books
- Cooking for friends
- Going to a wedding
- Buying a computer
- Going to a graduation
- Going shopping
- Going for a walk
- Buying a mobile phone
- Join a gym

7.2.3. Experimental task (TEMPO)

The memory task was built in Open Sesame Software and it is composed of three phases:

- **Anagraphical section**: participants filled questions at the beginning of the experiment. They were invited to indicate their surname (which were used in the next block to elicit the association to personal events), age and sex.
- **Learning block**: participants needed to memorise a list of six event associated with a specific year. They were invited to memorize the events as being part of their real autobiographical memory. Each event was associated to one specific year, distant from the central one (the present year) on multiple of three or four years.
  The stimuli were presented in the middle of the screen with a font size of 30 pixels. The experiment was administrated using the same monitor (resolution 1920×1080 pixels) and the same keyboard for all participants. Participants were sitting at approximately 50 cm from the screen. Every event was presented for 5 sec. At the end of each cycle, participants were invited to associate the events to the corresponding year with the numerical keypad by pressing keyboard from 1 to 6. (See Fig. 7.1). The cycles minimum of presentation were 5. Once the participant reached 100% accuracy, he/she could move to the next phase. Unless he/she repeated the cycle until 10 repetitions. Participants who were not able to memorize within 10 cycles, were excluded from the RT's analysis.

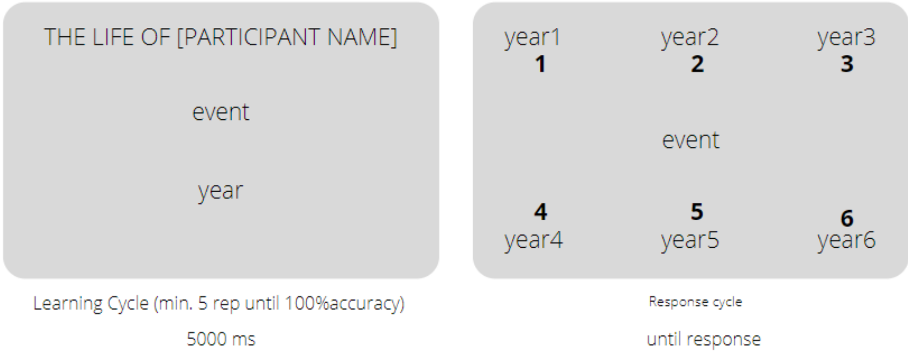

Fig. 7.1. *Learning block procedure. On the left, the representation of the phase in which participants learned all the events associated to a specific year. After each cycle, they were asked to associate the event to the correct years. Accuracy responses were collected.*

- **Mental time block** (Experimental): After learning the events, participants were invited to judge the sequence of each event in relation to the central event (2019/2020 for young adults and 2012 for older adults). They were instructed to briefly mentally retrieve their life and the events they saw in the previous block. Then they were invited to focus on the present and the central event: taking part to a psychological experiment. Participants were invited to collocate the events before the present in the past, and the events after the central event in the future. The allowed buttons were A (on the left-side of the keyboard) to select the stimulus of the past and L (on the right-side of the keyboard) to select the stimulus of the future. (See Fig. 7.2). They were invited to answer as accurate and fast as possible. Young participants had a 3 sec limit to answer, while older adults had no limit to answer, even if they were invited in any case to answer as fast as they could. They performed a cycle of practice before starting with the experimental version. This block lasted approximately 5 minutes with 12 cycles for each event and a total trial number of 72 for each event list. Each participant performed the task two times, with two different blocks of events. In one block, the events were distant 3 years from each other, while in the other the distance was of four years.

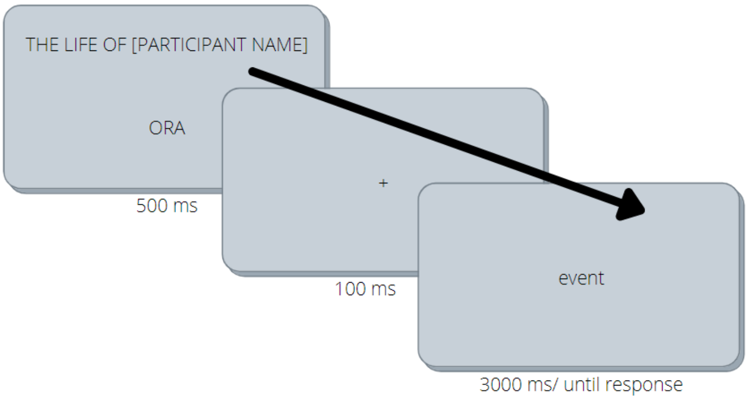

Fig 7.2 *Mental time block procedure. After a brief self-projection at the present moment, participants had to categorize events according to their position relative to the central event (NOW). They were invited to press A key (left side of the keyboard) for past events (before the central event) and L key for future events (after the central events. Accuracy and RT's responses were collected.*

- **Final recall block**: after the mental time block, participant's memory for the event was verified through a final association cycle, as in the first block of the procedure.

7.2.4. Procedure

Participants signed informant consent before participating at the research. After that, the experimenter gave a brief explanation of the modalities of the task. Each participant completed two blocks of events. They performed the experimental task at the begin and the end of the session. Between the two blocks, they underwent several neuropsychological memory tests.

- **LONG TERM MEMORY – PHONOLOGICAL: Rey's 15-word list** (Rey, 1958; Carlesimo et al., 1996): allows the assessment of learning and long-term memory of new verbal information. In the present study, immediate and delayed recall was required. The examiner read a list of words to the participant and invited him/her to repeat as many of the newly heard words as possible, in any order. The word list is repeated 5 times. After an interval of 15 minutes, during which the participants performed other memory test, they were asked to recall all the words they could recall. We used raw score of the two sub-dimensions: immediate, obtained by the sum of each correct recall of every cycle, and delayed obtained with the total of final recall of the words.

- **LONG TERM MEMORY – VISUOSPATIAL:** Rey-Osterrieth figure (Rey, 1941; Osterrieth, 1944; Caffarra et al., 2000): participants were invited to reproduce by drawing a no-sense image. In a first block, they performed the task with the original copy on the side. After 10 minutes, they were invited to recall the figure without visual support. Raw scores were obtained by the score for each part correctly recall (even partially recall or recall in the wrong position).
- **SHORT TERM AND WORKING MEMORY – PHONOLOGICAL: Digit span (Forward and Backward version)** (Orsini et al., 1987; Monaco et al., 2013): in the Forward version, which measures verbal short-term memory capacity, a sequence of digits is audibly presented and the participant is asked to repeat it in the same order. The sequence increases of length in order to test memory span. The participants were invited to answer until two-block error. Raw score was obtained by the maximum number of elements participants were able to recall properly. In the backward version, the procedure is similar to the forward version, but participants needed to recall in reverse order.
- **SHORT TERM AND WORKING MEMORY – VISUOSPATIAL:** Corsi test (Forward and Backward version) (Corsi, 1972; Monaco et al., 2013): as for the Digit span, participants needed to recall a sequence in the same and in reverse order. Experimenter touched cubes on a wooden board. After that,

the participant was invited to touch the cube in the same order (forward) or in the reverse order (backward). The raw score was obtained by the span, the number of correct cube recall in the proper order.

7.3. Results

We performed analysis on R Studio. Accuracy and reaction time were collected. We analysed the accuracy of the learning block. In the experimental block we confronted response times' logarithm for each dimension of the events: POSITION (1, 2, 3), indicating the distance from the central event and TIME (PAST, FUTURE), which indicate whether the event occurred before the centrale event or after. Response times analysed were only those associated with correct responses. Participants with an accuracy below 60% were excluded from the analysis. We divided the analysis for the two experimental groups.

7.3.1. Young adults

Learning block: we performed the analysis on R studio to describe accuracy of participants for each cycle learning. 20 out of 23 participants had an average accuracy above 80% already in the second cycle. Made an exception participants 15, 19, 21.

We then performed a logistic regression with correct responses as dependent variable and the presentation cycles as the independent variable, in order to assess the learning trend at each cycle. The model resulted significant ($X2 = 133$, $df=8$, $p < 0.001$). The probability of learning all the events increased after each cycle and already from the second cycle the probability of answering correctly was high ($Exp(B) = 2.452$, $p < 0.001$) and became almost certain at the third cycle ($Exp(B) = 7.621$, $p < 0.001$).

Experimental block: RT'S > 1500 ms were eliminated and participants with an overall task accuracy of less than 60% (participant 9) were removed. A linear mixed model was conducted with the logarithm of reaction time (performed only on correct response) as dependent variable, TIME (past, future) and POSITION (1, 2, 3) as factors and subject as random intercept. We found an effect of Position (F(1,1161.4)=19.599, p<0.0001).

This indicates that participants were quicker to respond when events were far from the central event, whereas they took longer if events were close (See Fig. 7.3).

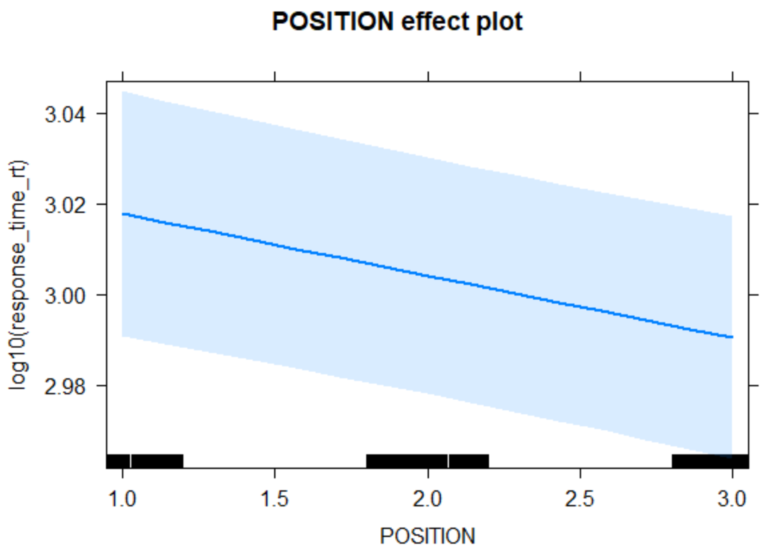

Fig. 7.3 *Distribution of event RTs relative to the central event (0).*

We extracted from the model a random slope and we compared the slope of each individual with the neuropsychological test z scores. Z scores were obtained with the mean and deviation standard of the sample validation. We conducted then a multiple regression with intercept slope as dependent variable and z scores of each cognitive test as predictors. The model (F (7,13) = 1.909, p = 0.155) explains 25% of the variance of the VD (R2 = 0.259) and is not significant. However, Corsi Backward score, predicts the value of the random slope (t=-2.738, p=0.0180). In particular, we observed that as the Corsi Backward values increased, the value of the random slope decreased (see Fig. 7.4). Consequently, the distance effect increased.

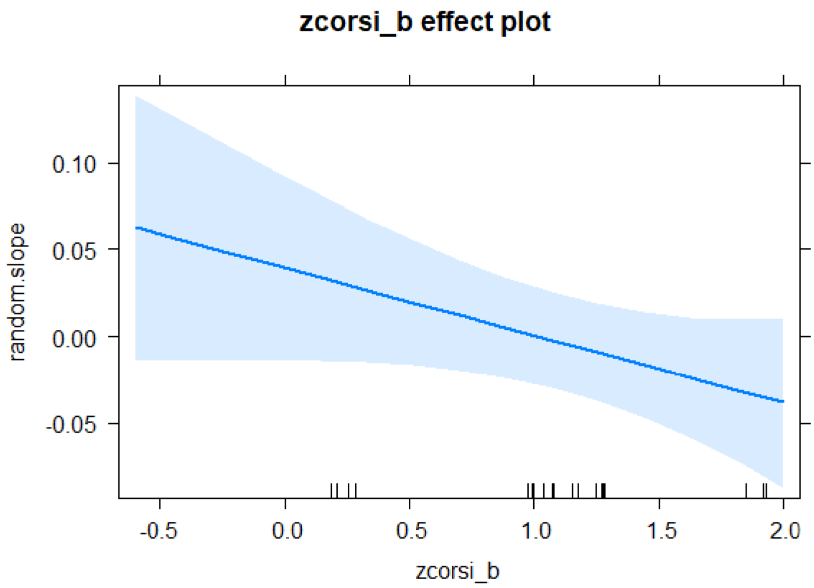

Fig. 7.4 *Distribution of the random slope and its relation with z score of the Corsi Test backward.*

7.3.2. Young old group

1. **Learning block:** we performed descriptive analyses on R studio to describe accuracy of participants for each cycle learning. Five participants never reached the 100% accuracy within the ten cycle. Moreover, most of the participants reached the total accuracy after the fifth cycle, except for one participant. We performed then a Generalized Mixed Models with correct responses as dependent variable and the presentation cycles as the independent variable, in order to assess the learning trend at each cycle. The model reached the significance (X2 =79.5, df=9.00, p< 0.0001). The probability of learn all the events increased after each cycle. Although it increased until

the fifth cycle (Exp(B)= 5.07, $p < 0.0001$), it never reached the absolute certainty of remember all the events.

2. **Experimental block:** RT'S > 1500 ms were eliminated and participants with an overall task accuracy of less than 60% (participant 3) were removed. A linear mixed model was conducted with the logarithm of response time (performed only on correct response) as dependent variable, TIME (past, future) and POSITION (1, 2, 3) as factors and subject as random intercept. We found an effect of Position (t=2.264, p=0.023). This indicates that participants were quicker to respond when events were far from the central event, whereas they took longer if events were close, reflecting a classical distance effect as in the young adults group. (See Fig. 7.5).

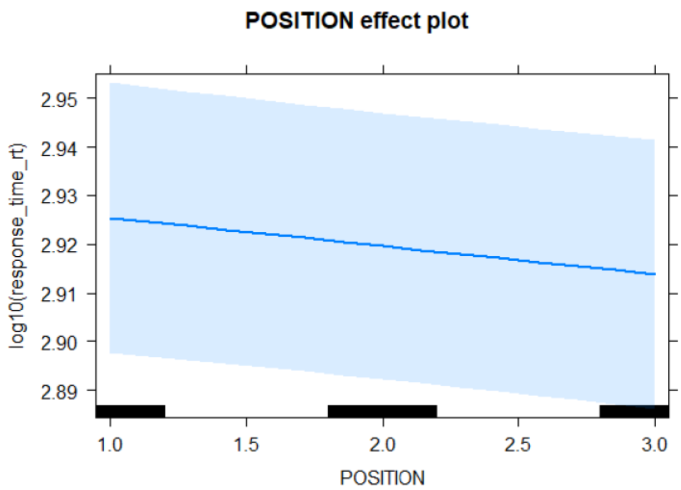

Fig. 7.5 *Distribution of event RTs relative to the central event (0).*

We extracted from the model a random slope and we compared the slope of each individual with the neuropsychological test z scores. We conducted then a multiple regression with intercept slope as dependent variable and z scores of each cognitive test as predictors. The model ($F(7,13) = 1.909$, $p = 0.155$) explains 49% of the variance of the VD ($R^2 = 0.492$) and is not significant ($p>0.05$).

7.4. Conclusions

This study is a first attempt of creating a new episodic memory task that, with the knowledge about distance effect and spatial distribution of temporal item, aims to quantity the ability of individuals of remembering some events. After a classical learning cycle presentation, participants were asked to judge the position relative to a central event. We expected the positions that were far from the central event should have been easier to identify, while close events should have been harder to collocate, according to a spatial representation in the long term memory.

The present work focused on a sample of young adults and young old participants, which, unfortunately, due to global health emergency, was not sufficient to allow statistical comparison (24 young participants vs. 17 young old). In line with previous studies by Arzy et al. (2008; 2009) and Gauthier and Wassenhove (2016), this pilot study suggests a distribution of learned events according to an egocentric personal timeline, supporting the hypothesis that time is mentally represented according to a spatial format (Bonato et al., 2012). This indicates that participants spatially map events, in the past and future. This ability seems to be present in both younger and older participants. However, the learning process of these events seem to be harder for older adults, underlining how this kind of task could be high demanding for an older population, even though the performances at neuropsychological tests did not indicate any long, short or working memory issue. Moreover, we aimed to quantify the effect size of this task with a random slope calculated for each participant. This measure could be used to compare different population and performance with other memory task. Furthermore, the mental time line seems to be correlated with a general performance at spatial working memory. We did not observe in our sample any influence of other cognitive tasks in the older population, that requires at least a larger sample size. Our study presents some limitations. We considered the episodic personal event learned in this task as “really” learned in an ecological context. However, autobiographical events could reflect a different pattern. Further studies will be able to overcome this limit with the aid of the virtual reality paradigm as in Abichou (2021) or with a previous collection of personal events (counterbalanced for distance among years and emotional arousal). However, this study represents a first attempt towards the creation of a valid personal episodic memory task.

8. CONCLUSIONS -THE FUTURE IS UNWRITTEN

Fig 8.1. The future is unwritten- Shepard Fairey (Paris, 2020).

Time, age and memory are all concepts linked to each other by an invisible thread. It is not possible to understand older people without knowing what time and memory represent and means. The time that goes by and becomes more precious and conscious. The memory that reminds us who we are, what we have done during our life.

Working with older people means also asking questions about not only the sociocultural aspects but also the deepest meaning of becoming old. This thesis project is, hopefully, the start of a long journey directed of the raise of these questions: considering the importance of becoming "oldest" not only as a natural biological process but also under a multidimensional approach in which cognition, perception and attitudes are strictly related in the definition of the life span process. In the first part, I discussed the impact of ageism attitudes in the ageing process as a predictor of well-being, but also cognitive abilities preserved. In fact, ageism is strictly related to the future view of one's self. The attitudes that we have toward ageing (knowledge, empathy, behaviour) will become the attitudes that we will have in the future toward ourselves as older men and women.

The ageing process is a complex journey in which life experience, events, illness, and emotions have a determinant effect. Moreover, the way we decide to manage these difficulties will predict a huge amount of the process itself. According to Leventhal's self-regulation theory (1998), and Barker's definition of self-perception of ageing as a multidimensional construct (Barker et al., 2007), the ageing process is comparable to the illness process and how we decide to manage and interpret the illness will determine the final outcome. The dimensions of self-perception of ageing that operate throughout the life span are the timeline and chronic awareness of the ageing process, the consequences positive and negative that can affect our future life, our emotional representation about the ageing process. These dimensions are deeply influenced by the experiences and knowledge that we have about older people and ageing. From a cognitive perspective, a stereotypical representation of every category helps us to better understand the world around us with a less cognitive charge. However, as for every stereotype, these representations tend to become rigid and maladaptive. This is what happens also with ageism. However, the new technologies allow us to replicate some scenario unthinkable until some time ago. In the first part of this work, I also discussed some ethical recommendations in using virtual reality technology despite its potentiality. Nevertheless, these methodologies can be useful in the research field to simulate some categories, such as the elderly. We can directly study the impact of age representation online in young participants, by temporarily modifying body representations. Potentially the construct of embodiment and the Proteus effect can give us the chance to open a new research field in ageing: by (temporarily) becoming older without wait years or by studying differences within subjects without longitudinal study.

This approach may be interesting not only in the active ageing field but also may give us the opportunity to study the impact of some social representations in predicting other dimensions, even cognitive ones. For instance, we can verify whether young adults may have more memory loss problems or slower speed processing in tasks in which the embodiment of older bodies is activated.

Thus, make the studies of virtual reality stimuli more relevant than in the past since the level of realism, personalization, body characteristics or facial features may deeply influence this paradigm and should be considered and counterbalanced in this new kind of paradigm. On the other hand, alongside these indirect interventions such as working on methodologies and at different age levels, it is possible to work directly on the elderly to promote their well-being. One of the dimensions on which we have decided to focus concerns the field of memory. On the one hand, because it is one of the mechanisms most affected in life span. In addition, the experiences of memory are closely linked to the concept of identity and particularly "precious" in old age as custodians of life events and coherent narratives of the self. Notably, the first memory difficulties are associated with dementia worry and could negatively affect attitudes and behaviours that the elderly themselves can adapt to counteract the cognitive impairment.

We proposed a new cognitive training developed on the Constructive episodic simulation hypothesis that we called TIME, acronymous of Episodic Memory

Intensive Training. In fact, the name aims to evoke the conceptual mechanism on which it has been created: time. Memory and time are related. While we used to associate memory to a process looking at the past, we know that memory allows to “travel in time” and one of its function is to projecting ourself into the future. These abilities in fact allow to predict possible scenario and anticipate thought, feeling and behaviour. It is in fact a mental training of our present self who can learn how to cope with different situations. All these abilities are based on the experiences that we accumulate during our life. Even though the findings of our study and first group validation efficacy look very promising, we aim to integrate this cognitive training with other neuropsychological assessment, specifically with episodic memory tasks. TEMPO (Italian translation of time) has been proposed as a possible new assessing task for investigating temporally binding within the personal event learning process. Further studies would confirm its validity and reliability. The project has been realized in a narrative form so that participants can write and discuss exercises during the sessions. Therefore, this cognitive training could be implemented also as individual training, even though we prefer the small group training approach since they are more efficient in promoting a positive relationship with the same age.

The journey from the past to the future concerns ageism in young adults and self-perception of ageing in older adults. Furthermore, this journey allows moving on the mental timeline where our personal events and self-projection are spatially and temporally located.

Whether time is the concept that binds the ageing process and memory mechanism, we assume that working on the present is what allows us to promote proactive ageing and to build flexible and adaptive future scenarios. Therefore, we have the opportunity with this approach to work for older adults, within the time. Because the future is still unwritten.

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